



Reducing Geological Risk

The EMerald Solution

ET & EM

Einstein Telescope & EMerald Geomodelling

- Introducing how to manage Geological risk and uncertainty
- Airborne Geoscanning – what is it?
- Bedrock surface – where is it?
- Identifying and volumetrically estimating soil types
- Identifying boundaries and weakness zones in bedrock
- Summary – benefits, opportunities and limitations
- ET – tell us your challenges

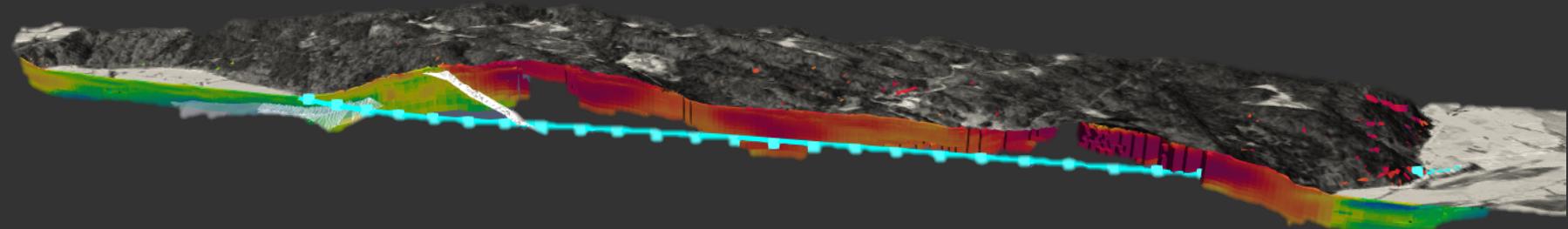


How to reduce risk?

Subsurface digital twin

Cover the whole project area

Direct extraction of volumes



Show the (physical) properties of the
material



The missing link

Geotechnical drillings

Cost & Time

Coverage low



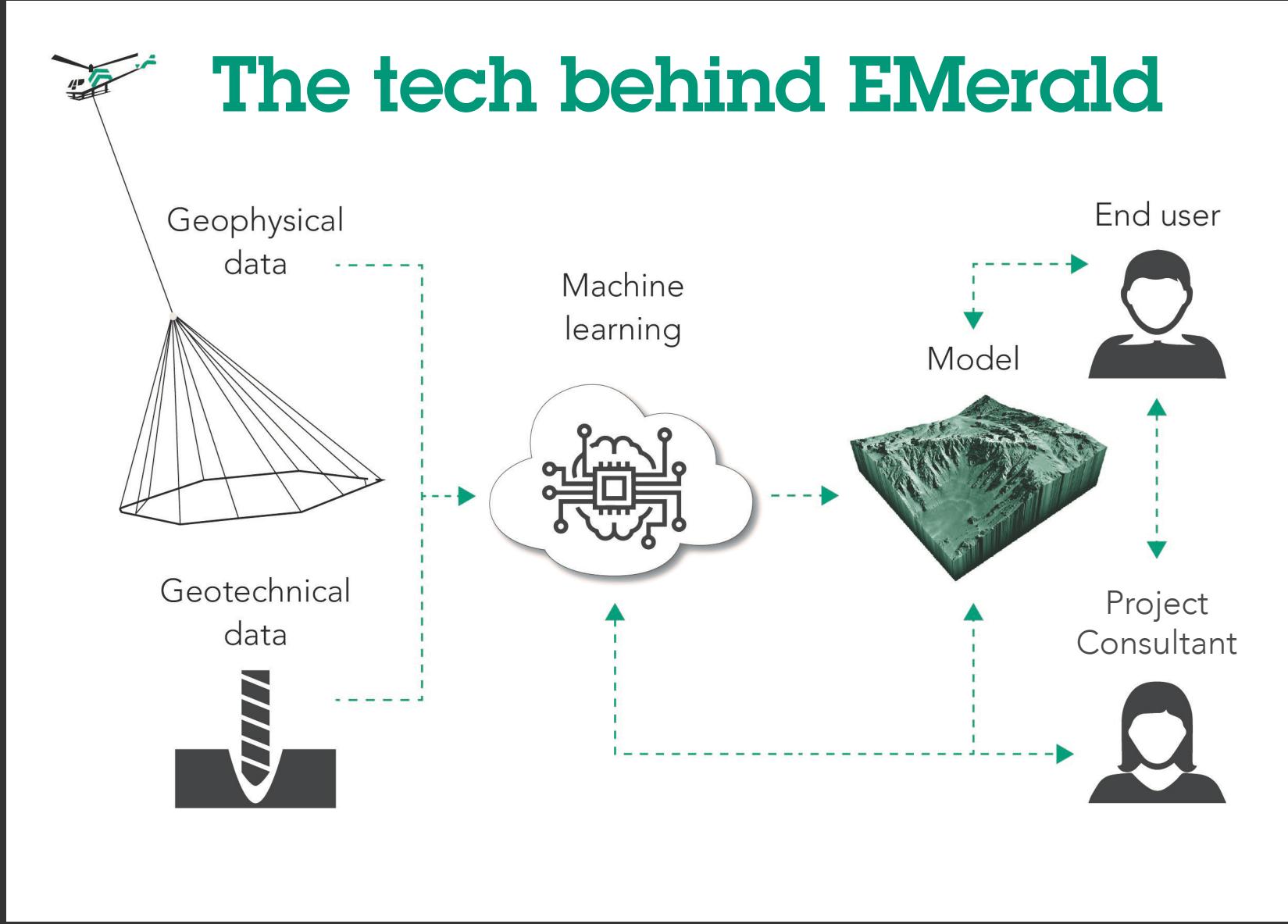
Airborne Geo-scanning

Coverage high & 3D

Complex



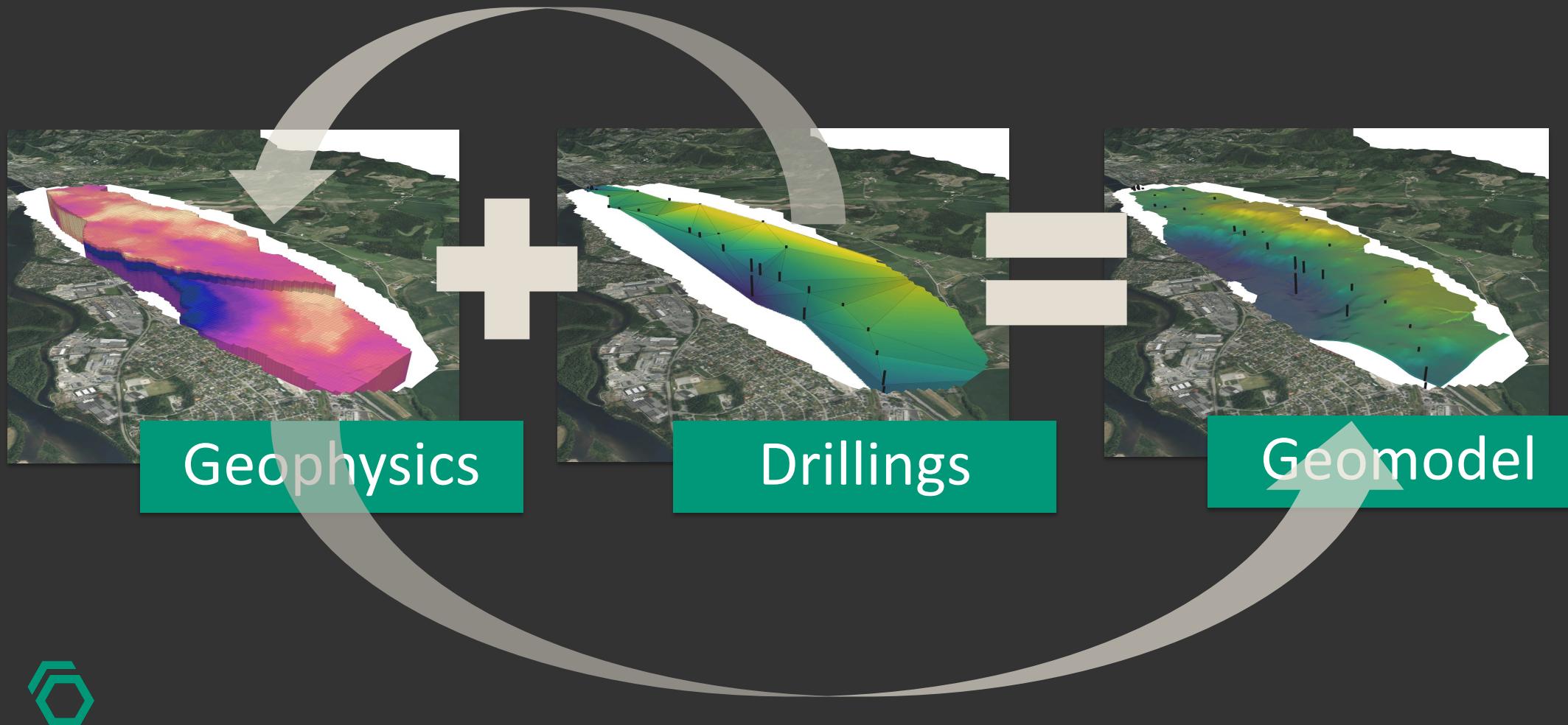
The tech behind EMerald



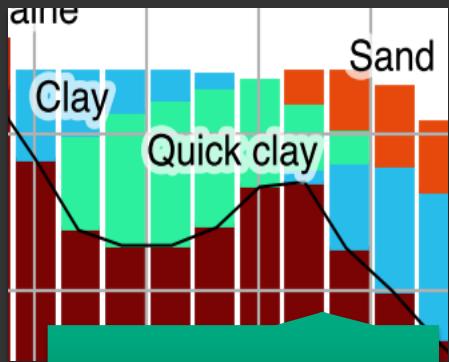
EMerald Geomodelling in a nutshell



Integrated & dynamic ground model



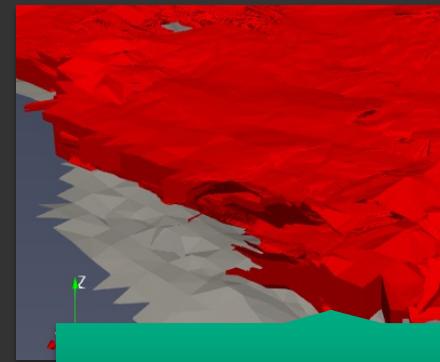
Focus areas



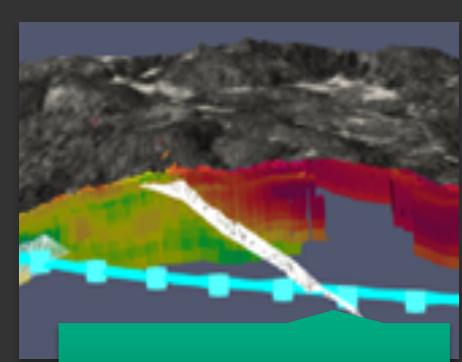
Fundamentals



Soil / Rock



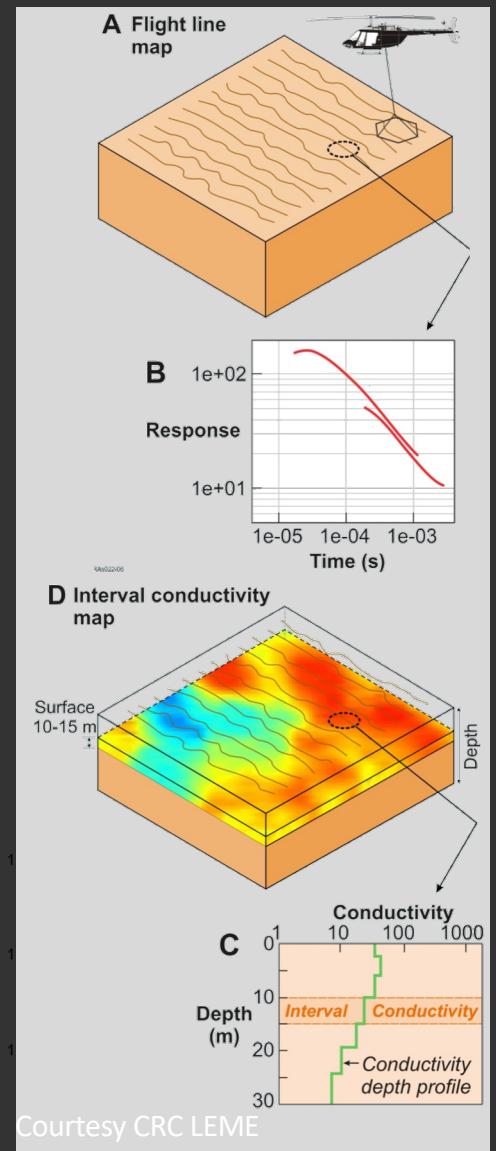
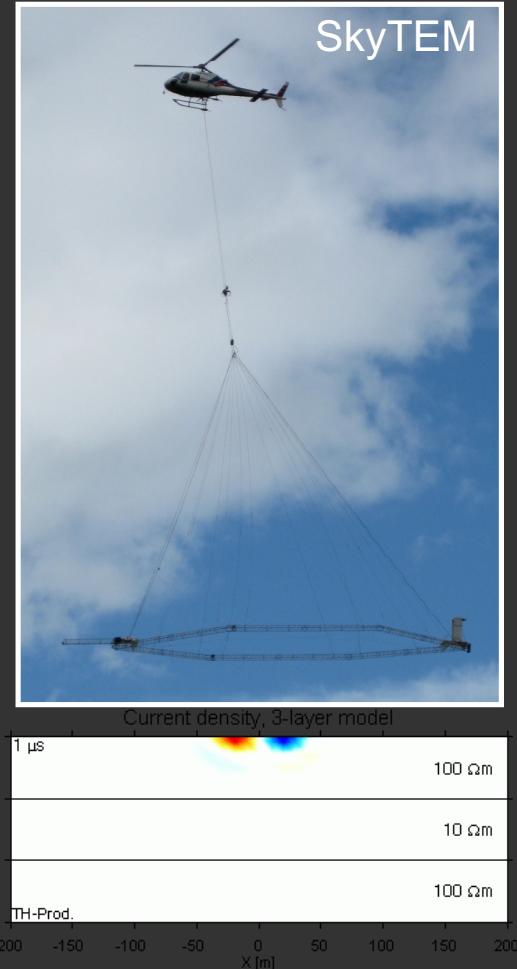
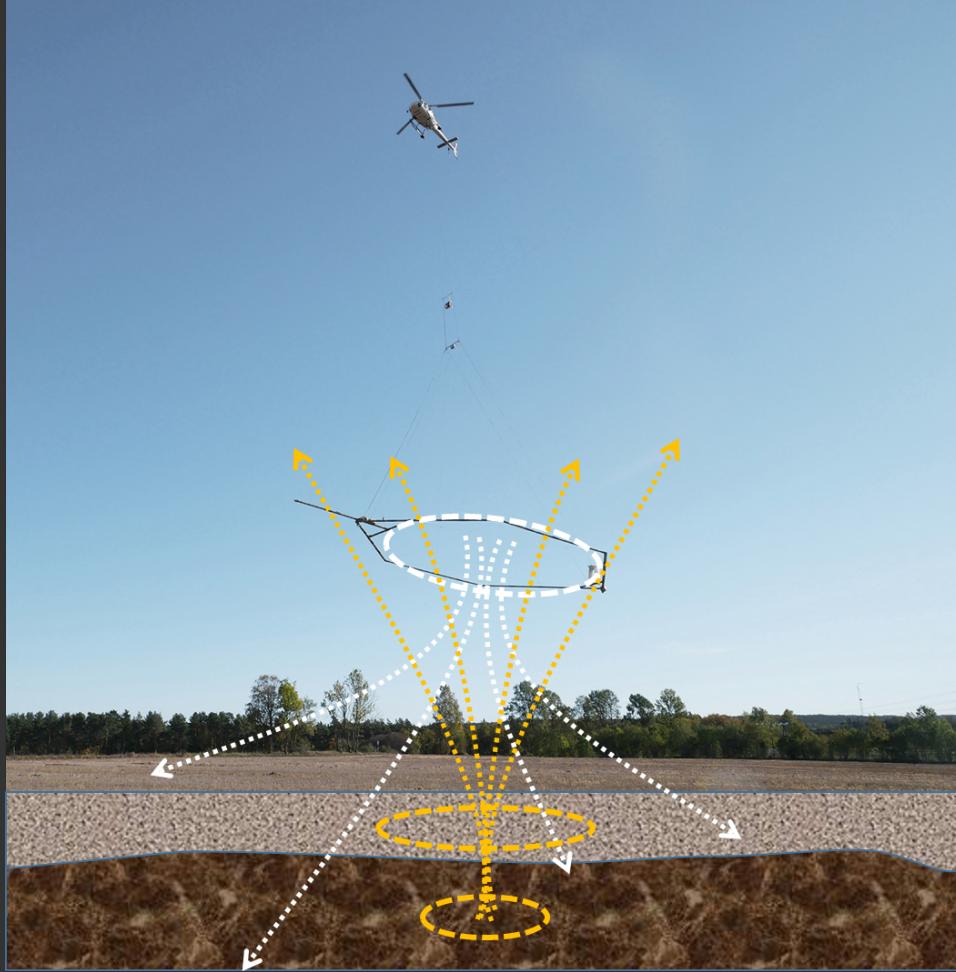
Soil types



Rock types



Helicopter Geo-scanning (AEM)

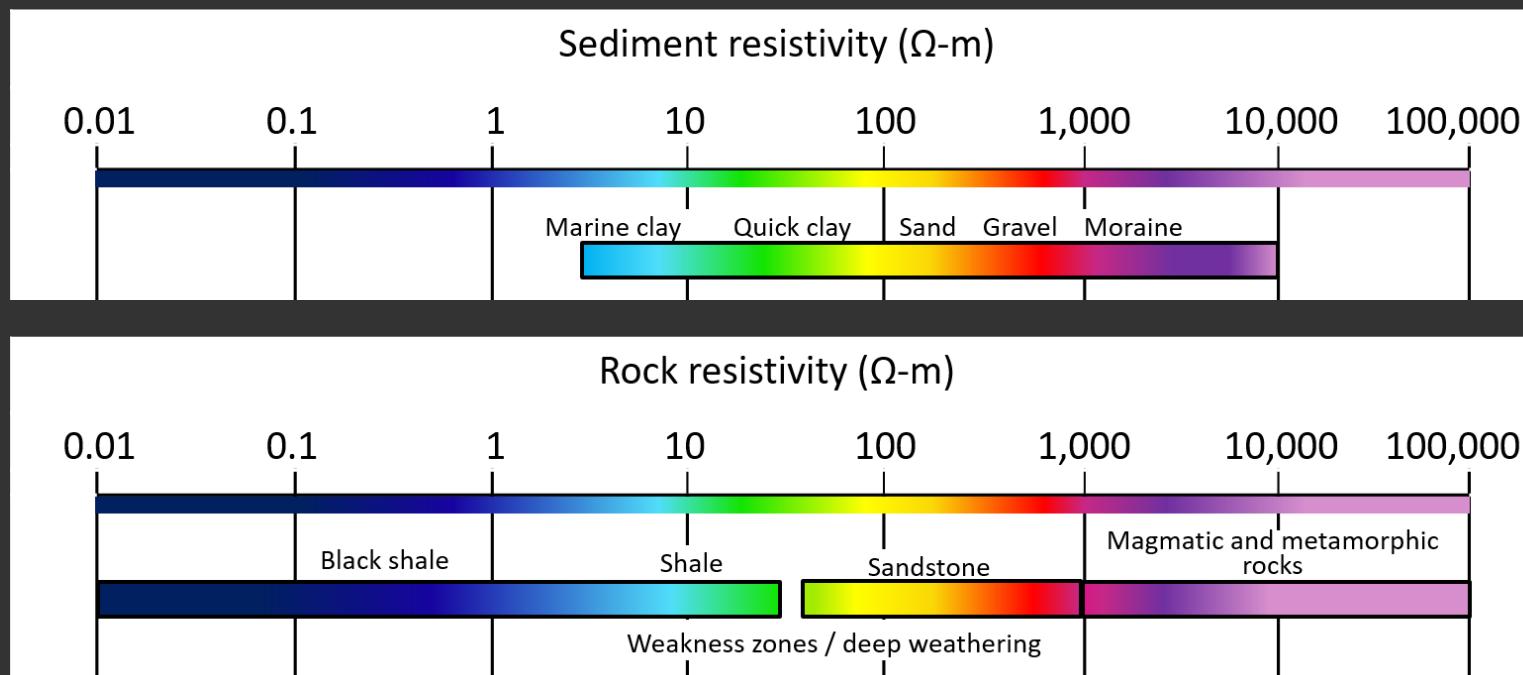


Courtesy CRC LEME

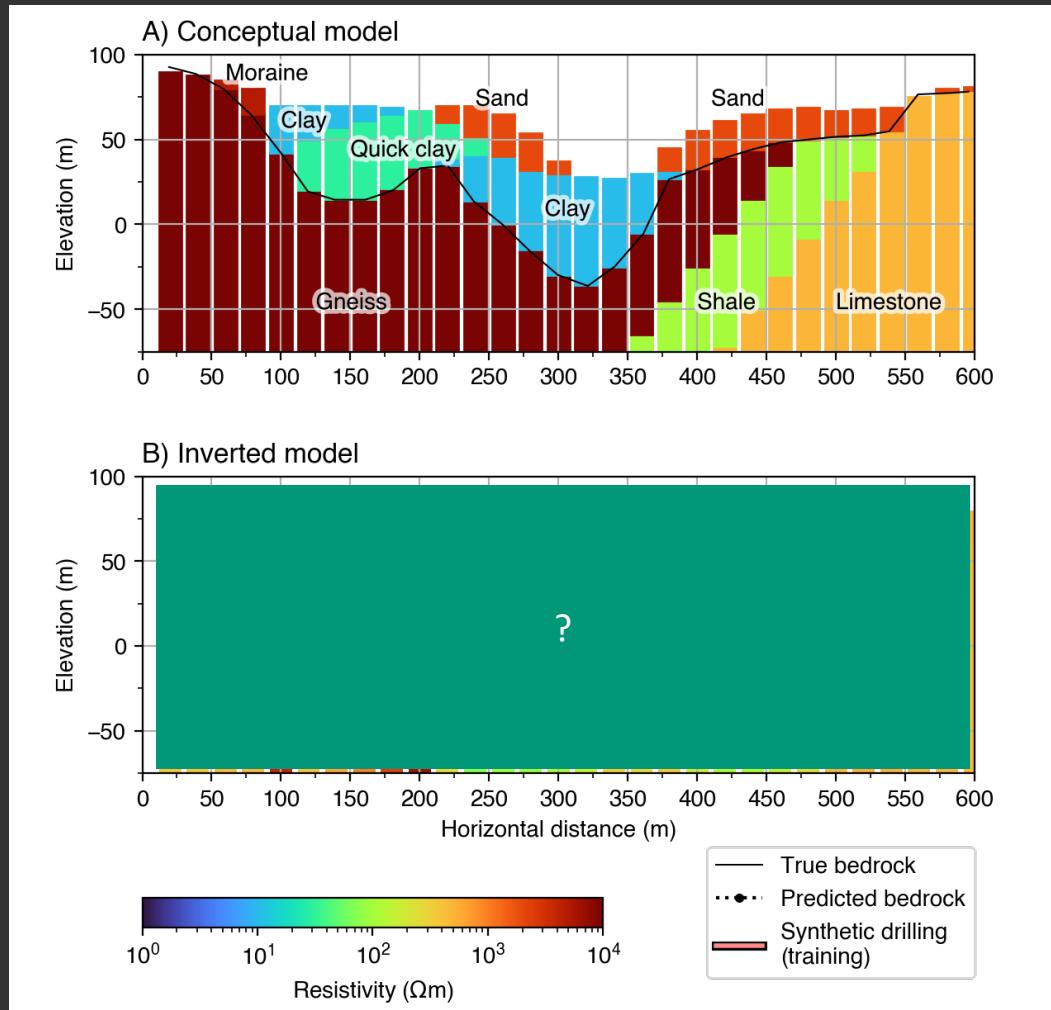


What do we see?

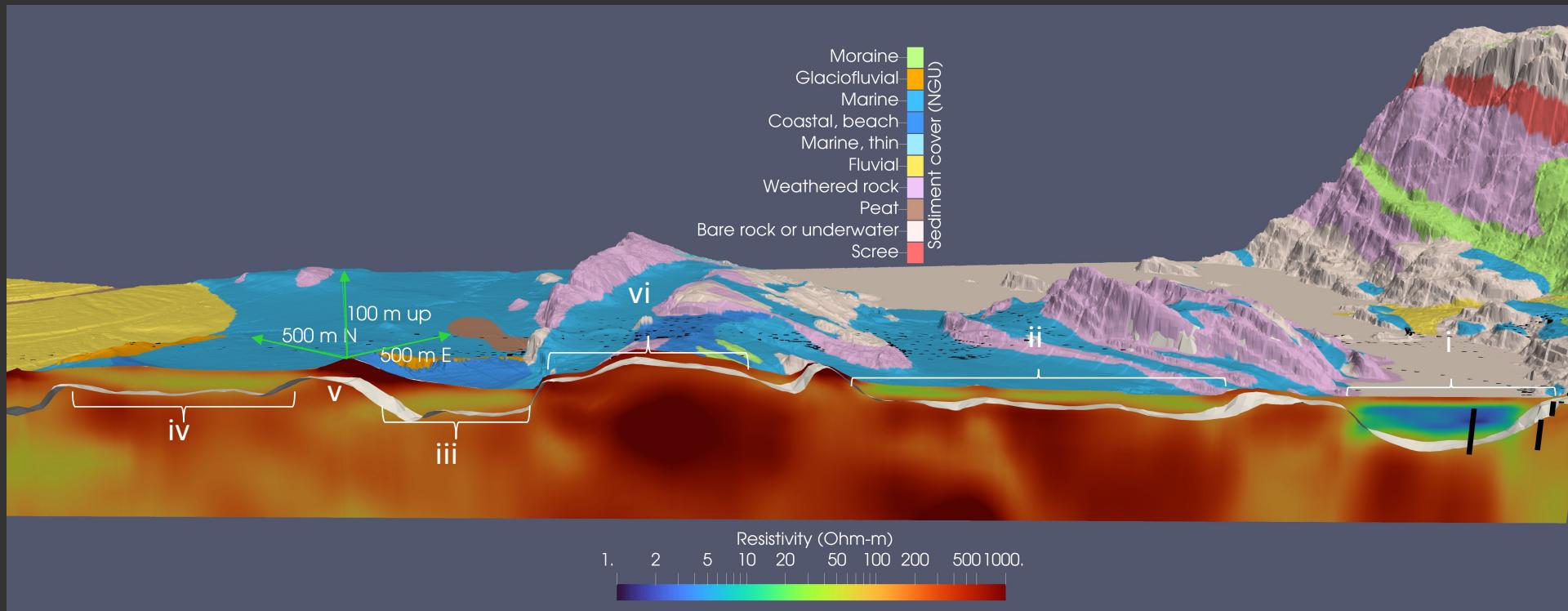
- Difference in resistivity for different Earth materials



How might this look like?

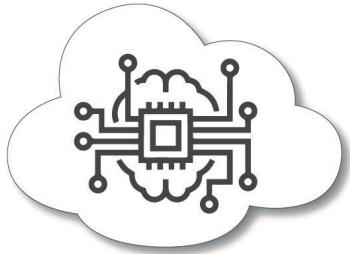


Real world complexity





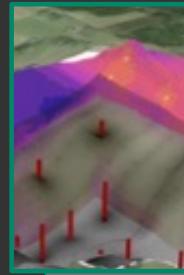
Machine
learning



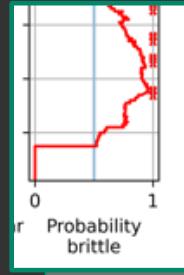
From real world complexity to model simplicity via



Clustering

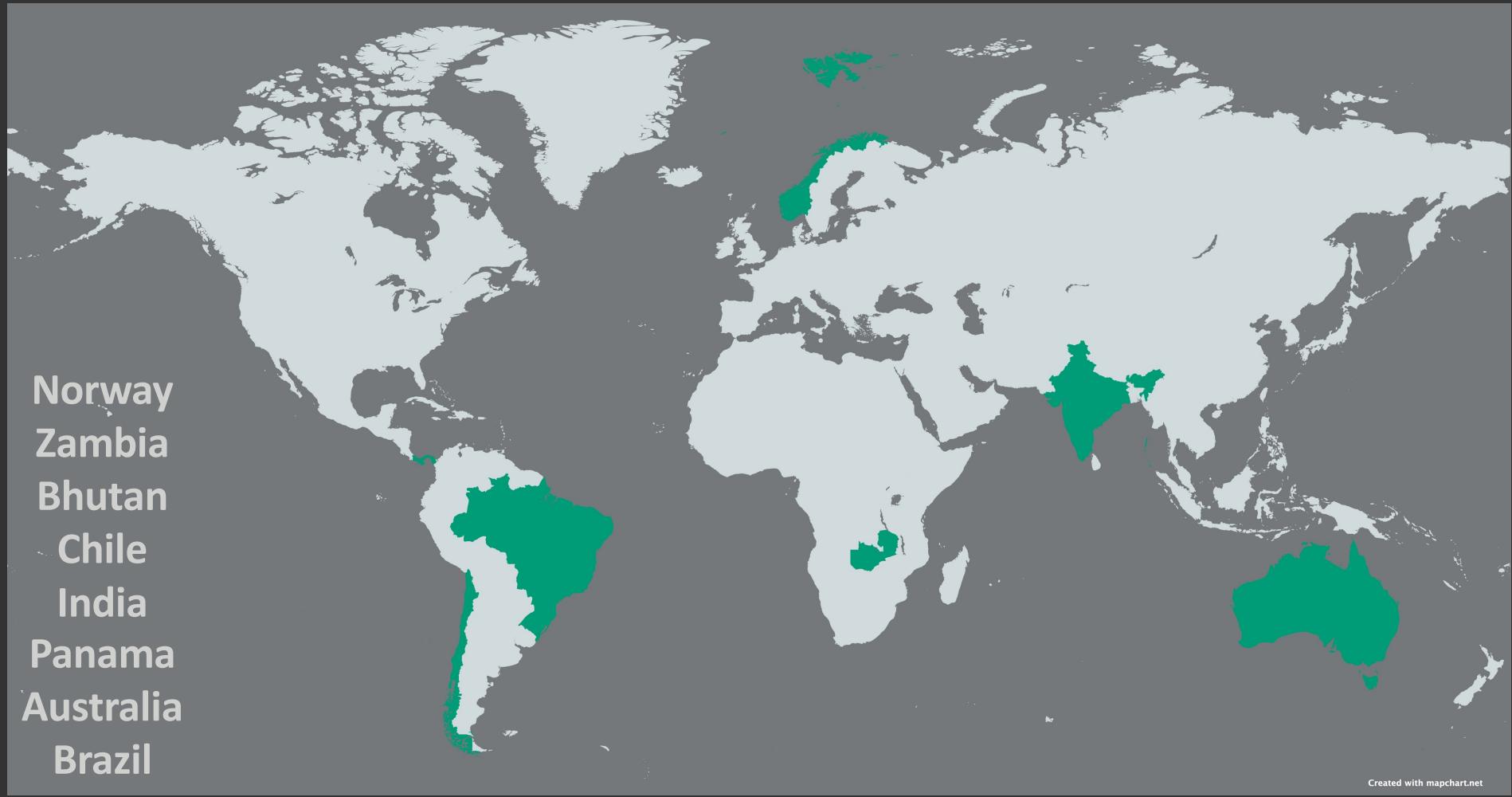


Interface
detection

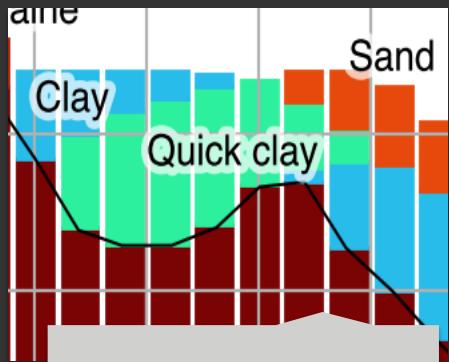


Material
classification

From the Scandes to the Andes



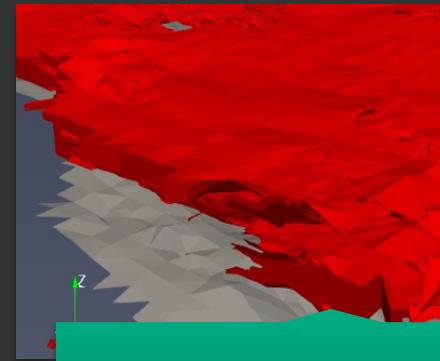
Focus areas



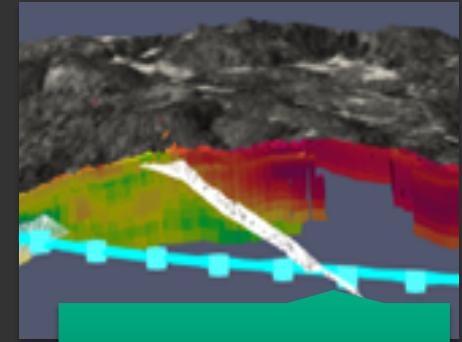
Fundamentals



Soil / Rock



Soil types

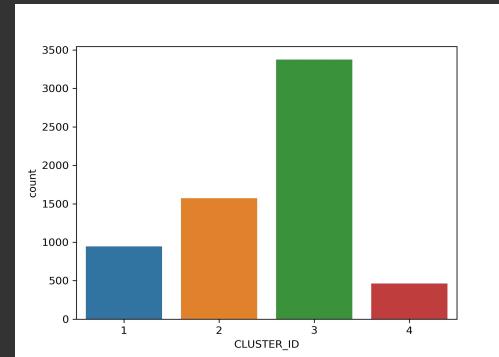


Rock types

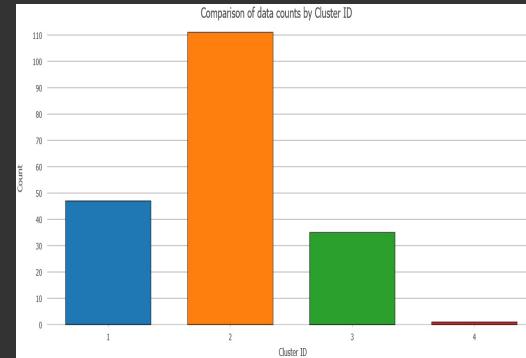


Geological heterogeneity

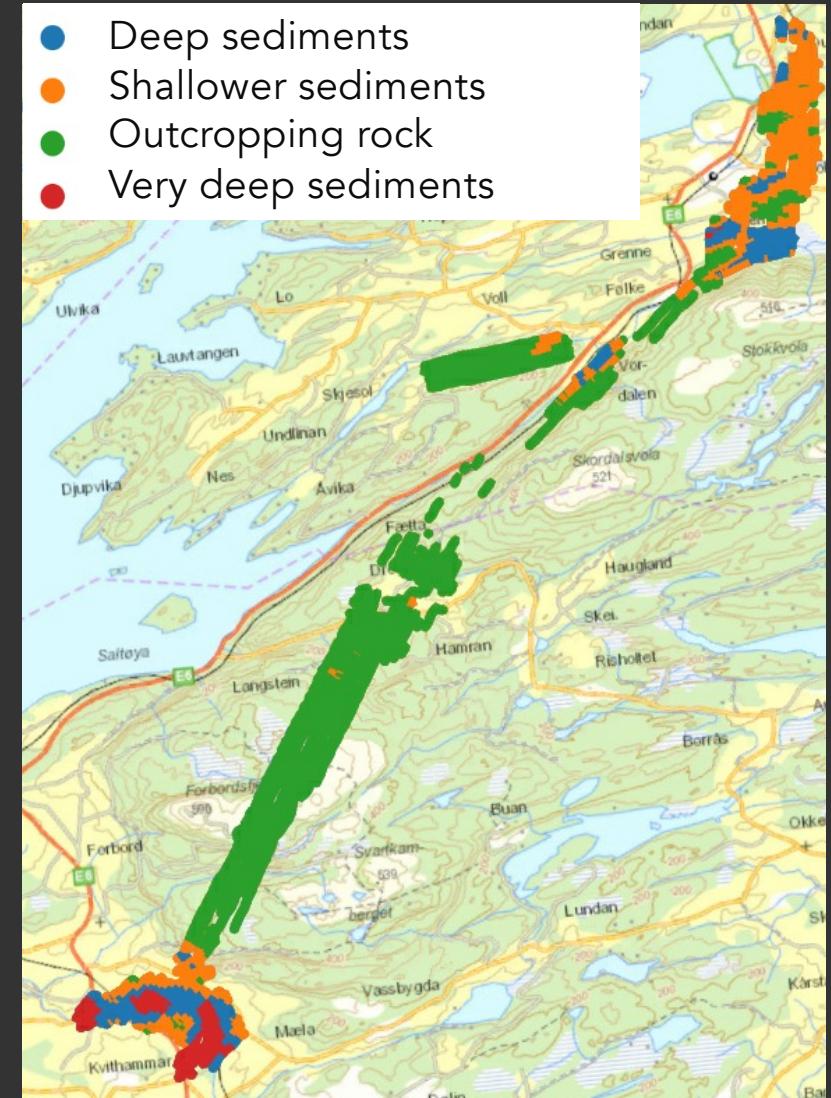
AEM



Existing Boreholes

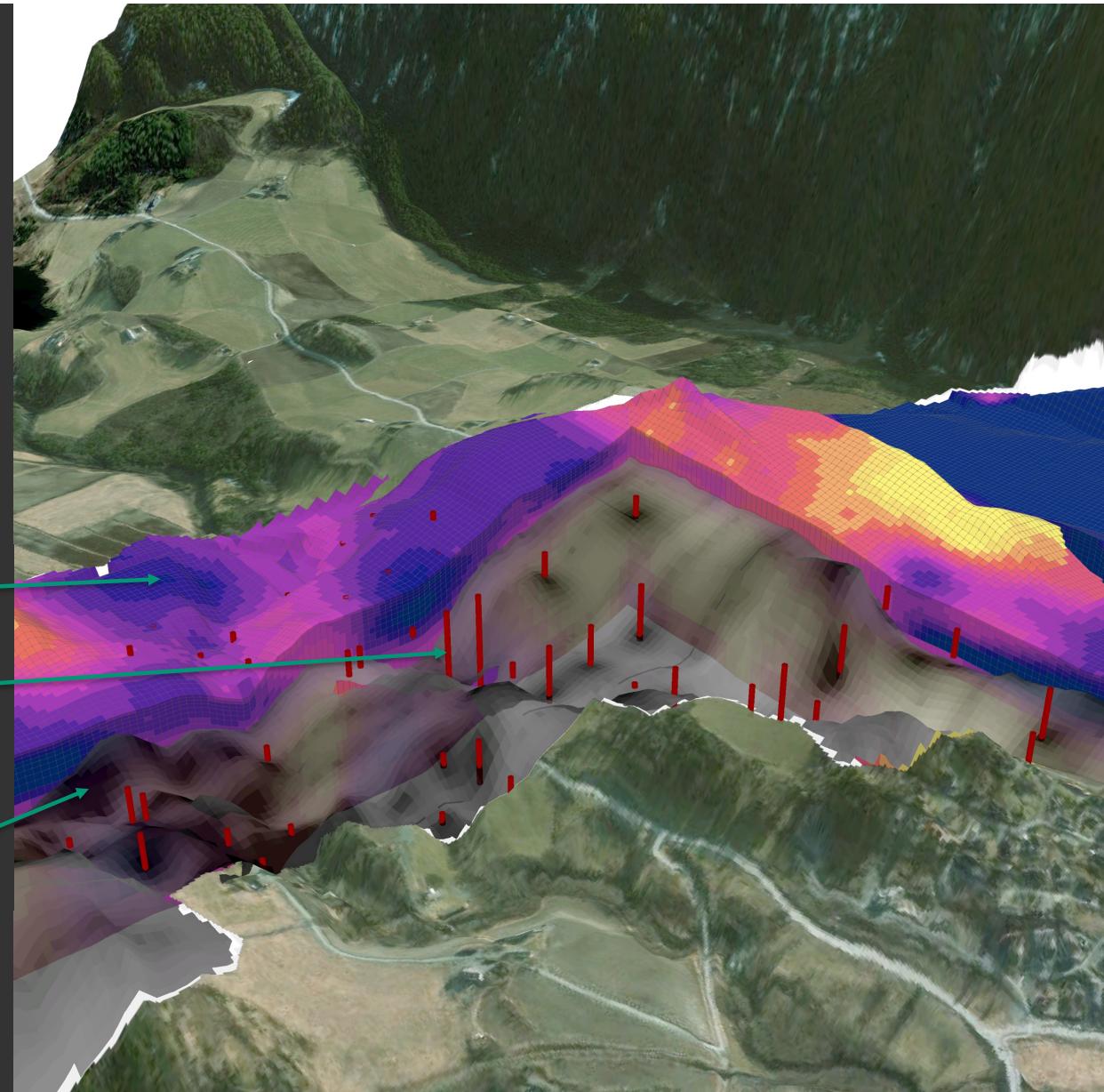


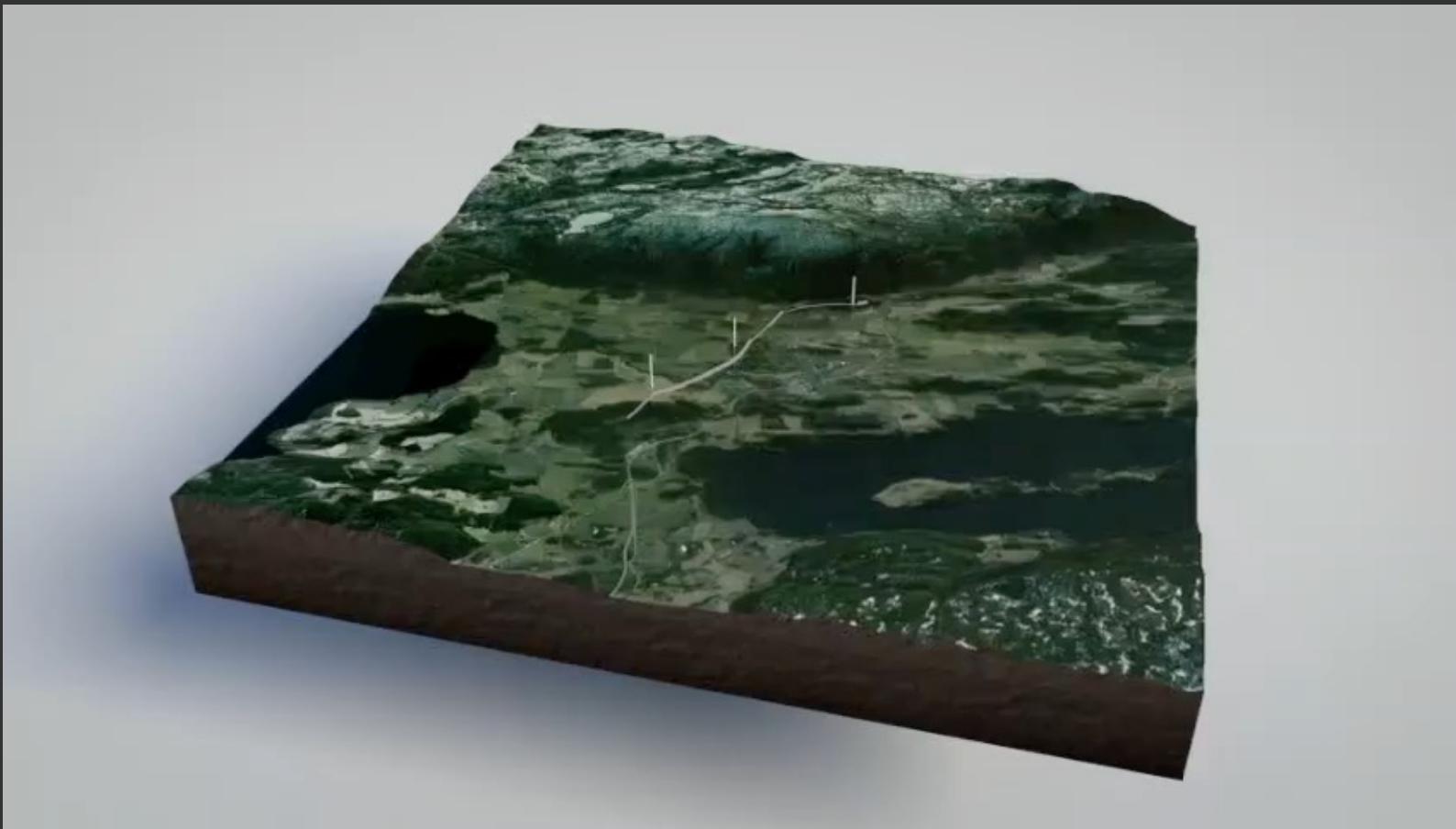
- Deep sediments
- Shallower sediments
- Outcropping rock
- Very deep sediments



Project example – Nye Veier E6 Trøndelag

- 3D resistivity model
- Drilled to bedrock
- Bedrock surface shaded by certainty





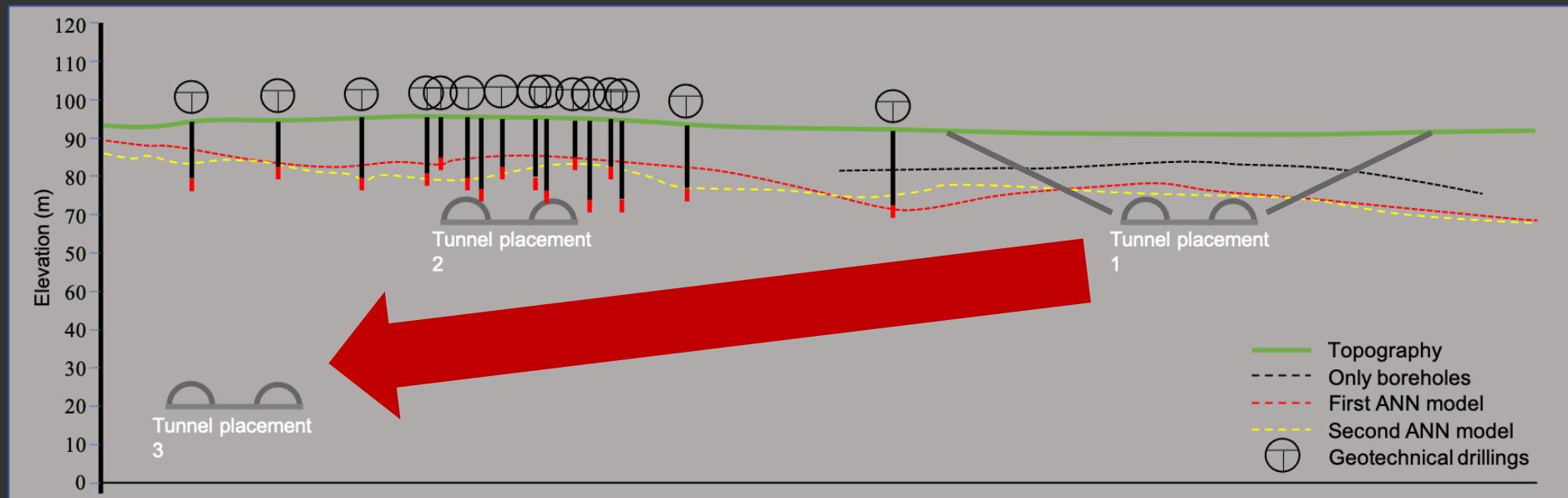
**"We will save up to 30 percent
of the ground investigation costs"**



Kari Charlotte
Sellgren
Technical Lead
Tunneling
Nye Veier



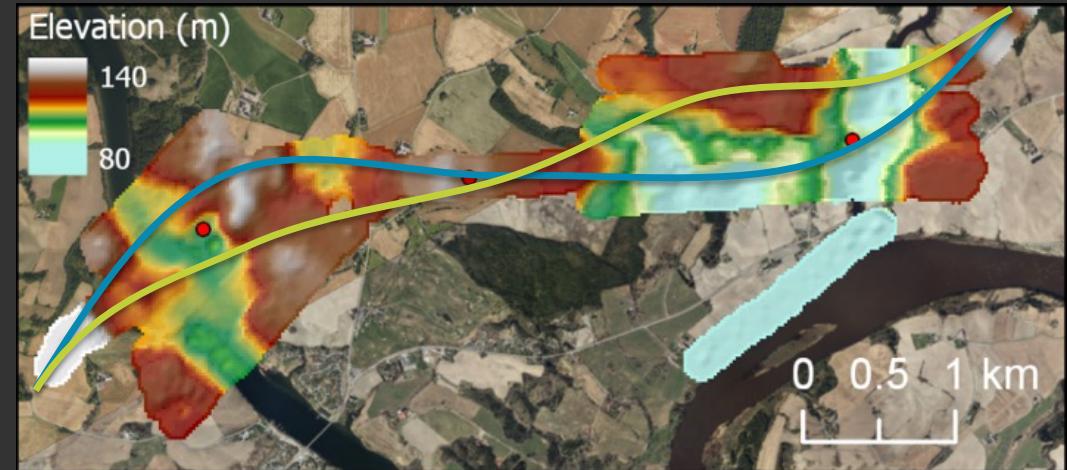
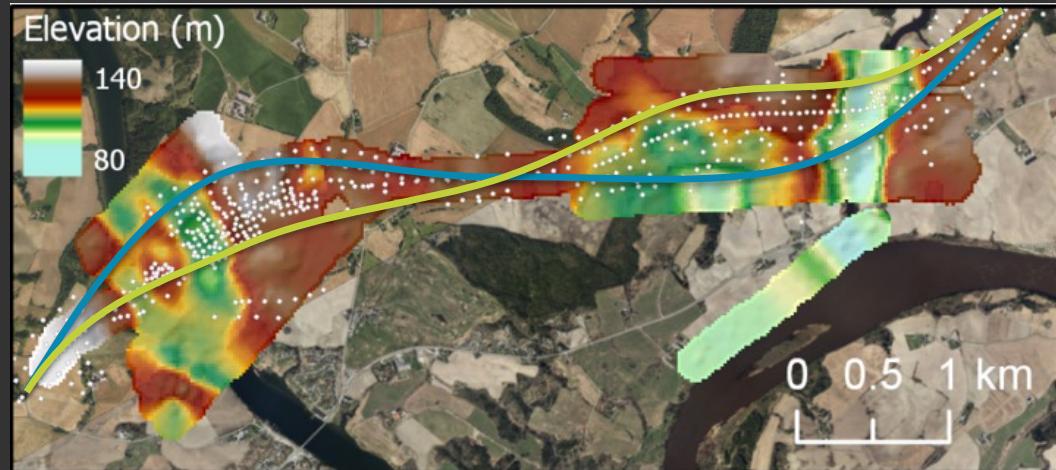
Indirect savings - 30% to \$ 24.000.000,-



Courtesy A.K. Lund, NGI 2020



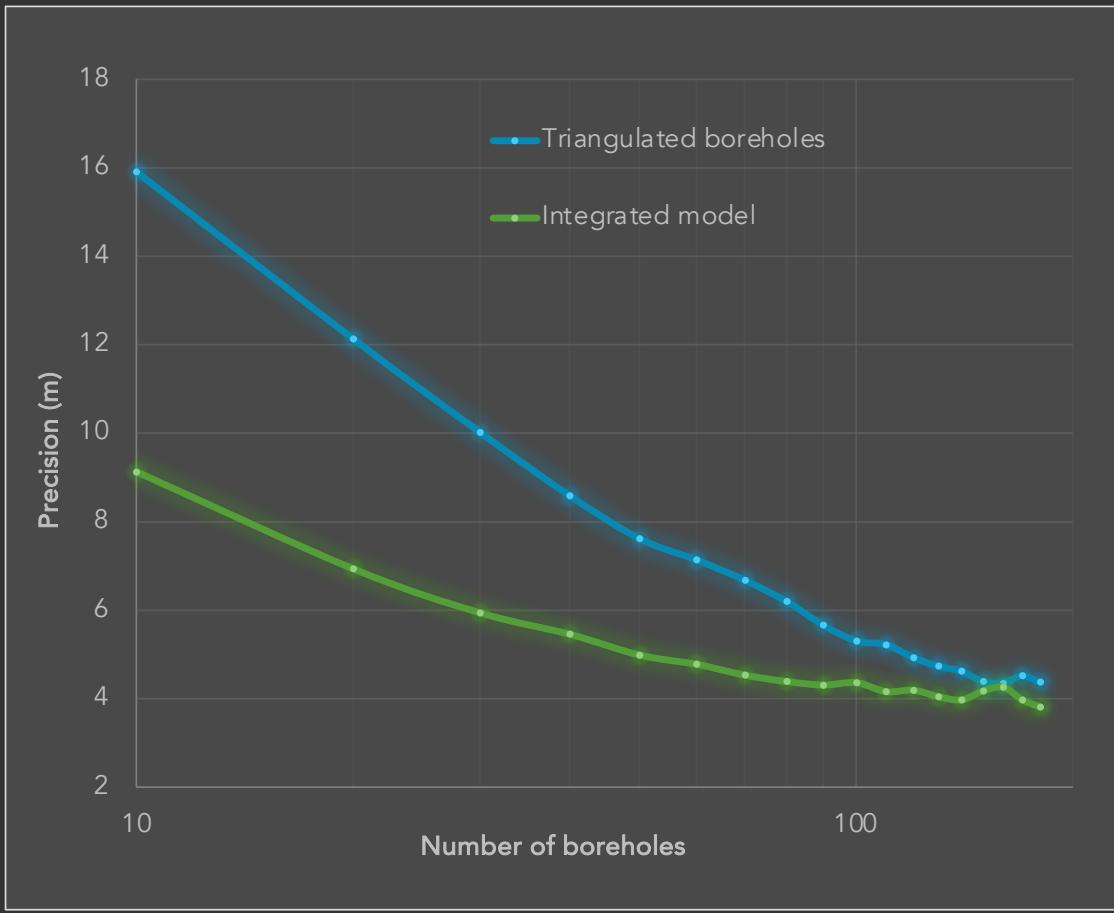
Model validation



100s boreholes versus 3 boreholes



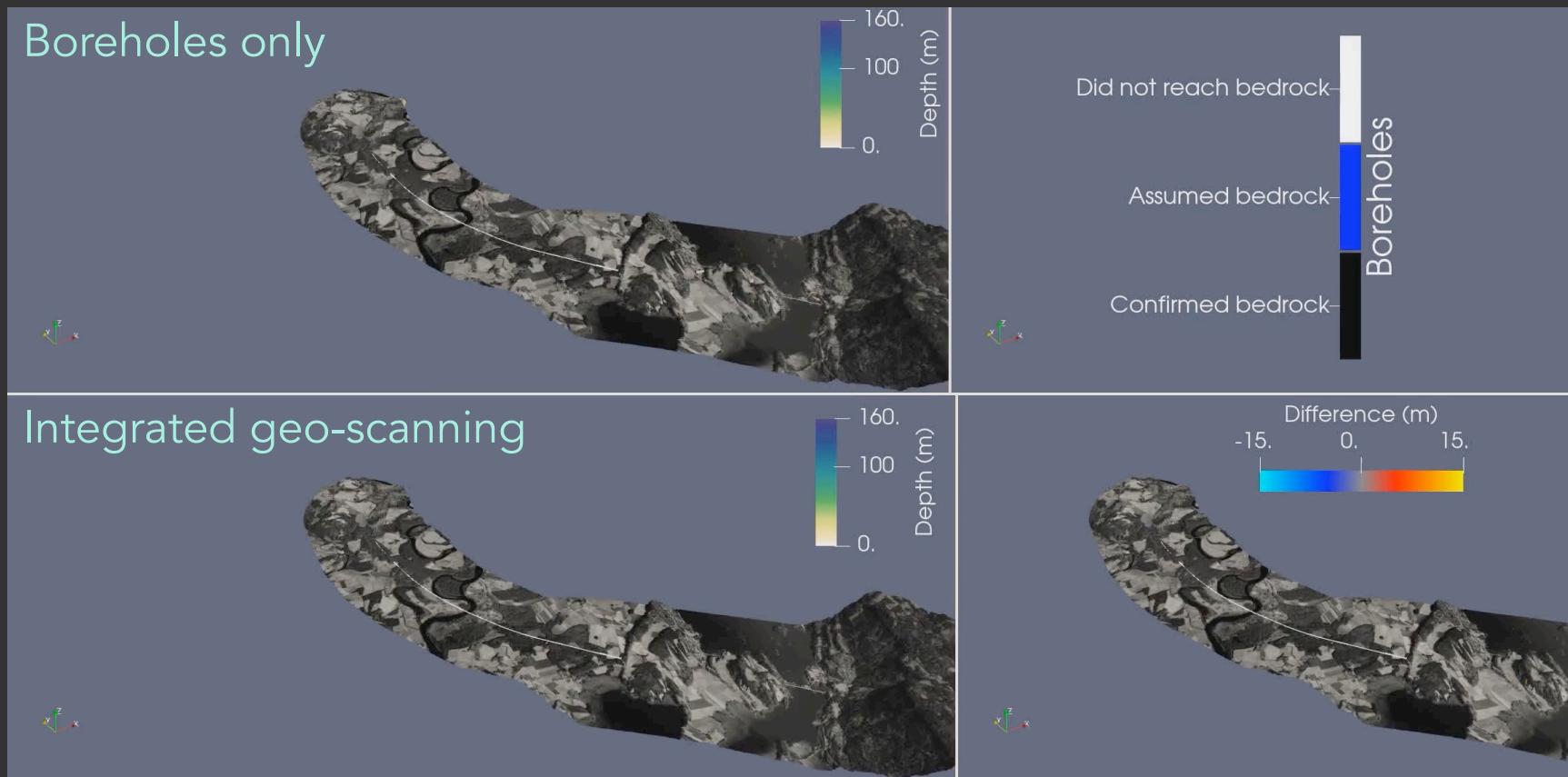
Accuracy & Efficiency



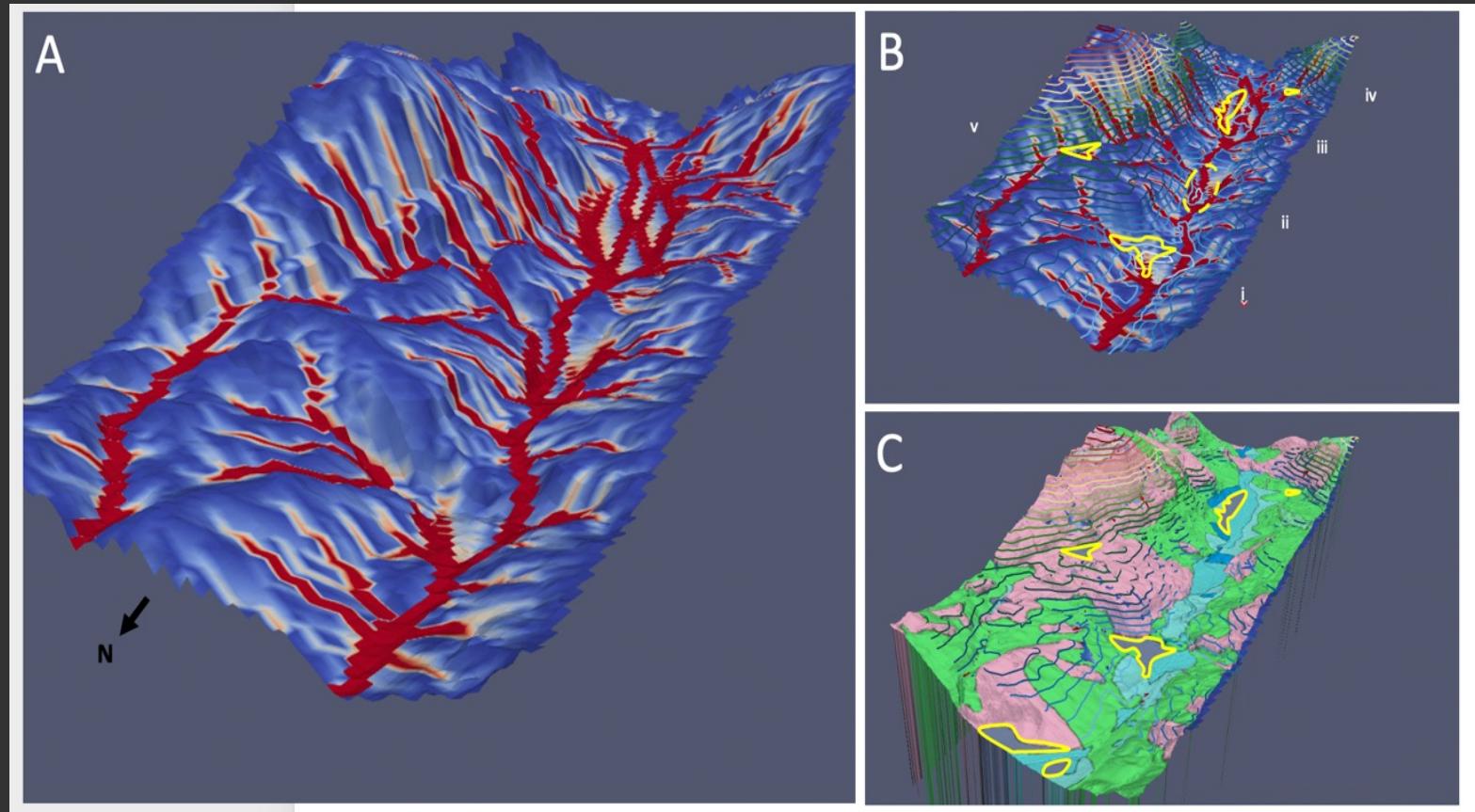
Drillings per square km		
Target Accuracy	Drillings only	Combined method
60 %	3 – 8	0.3 – 0.4
30 %	7 – 10	2 – 8



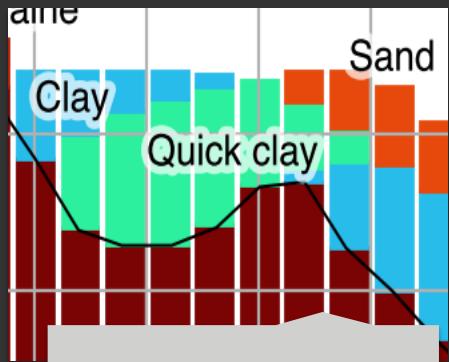
Bedrock model comparisons



Groundwater run-off model under tens of meters of cover



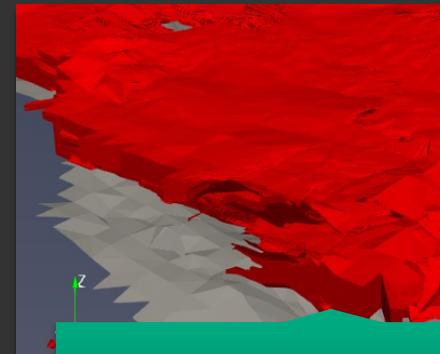
Focus areas



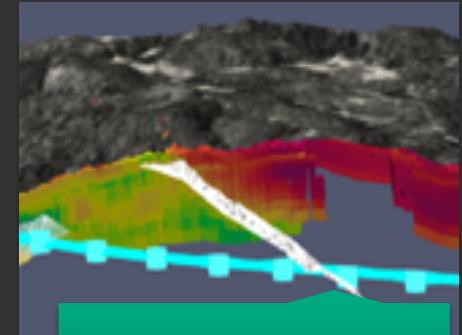
Fundamentals



Soil / Rock



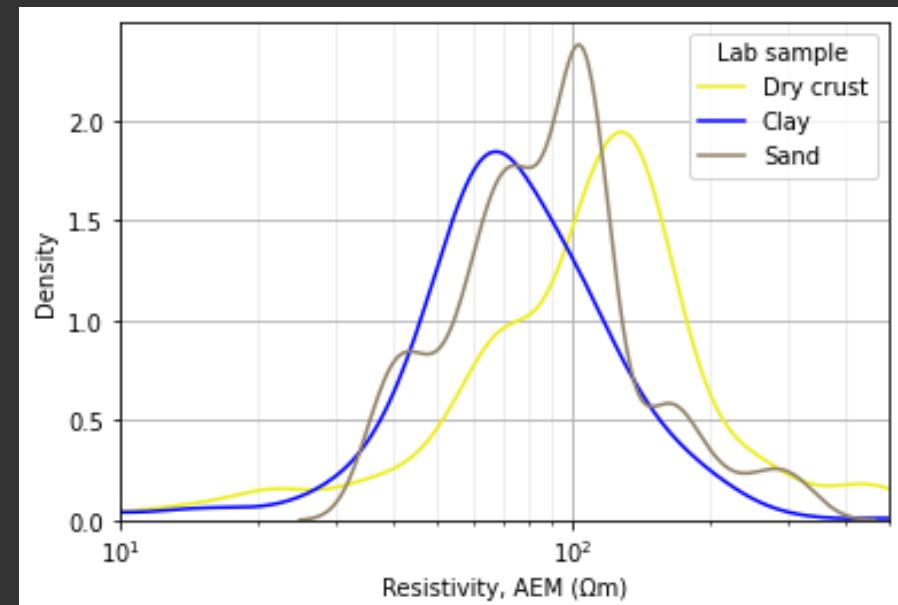
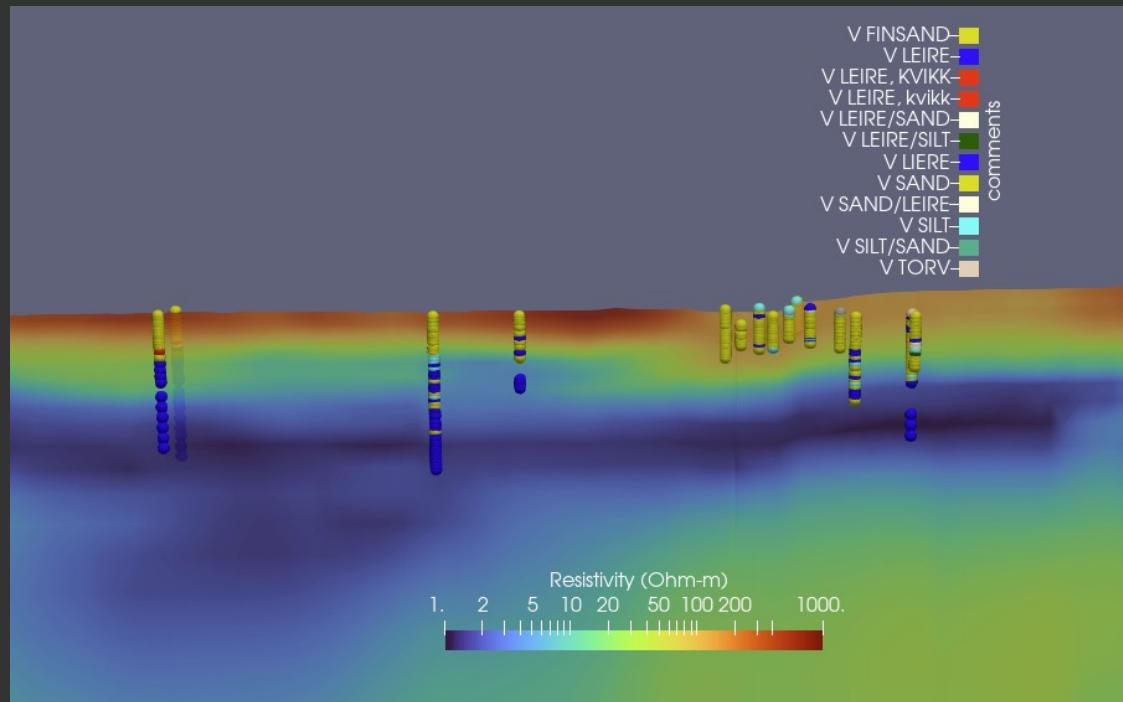
Soil types

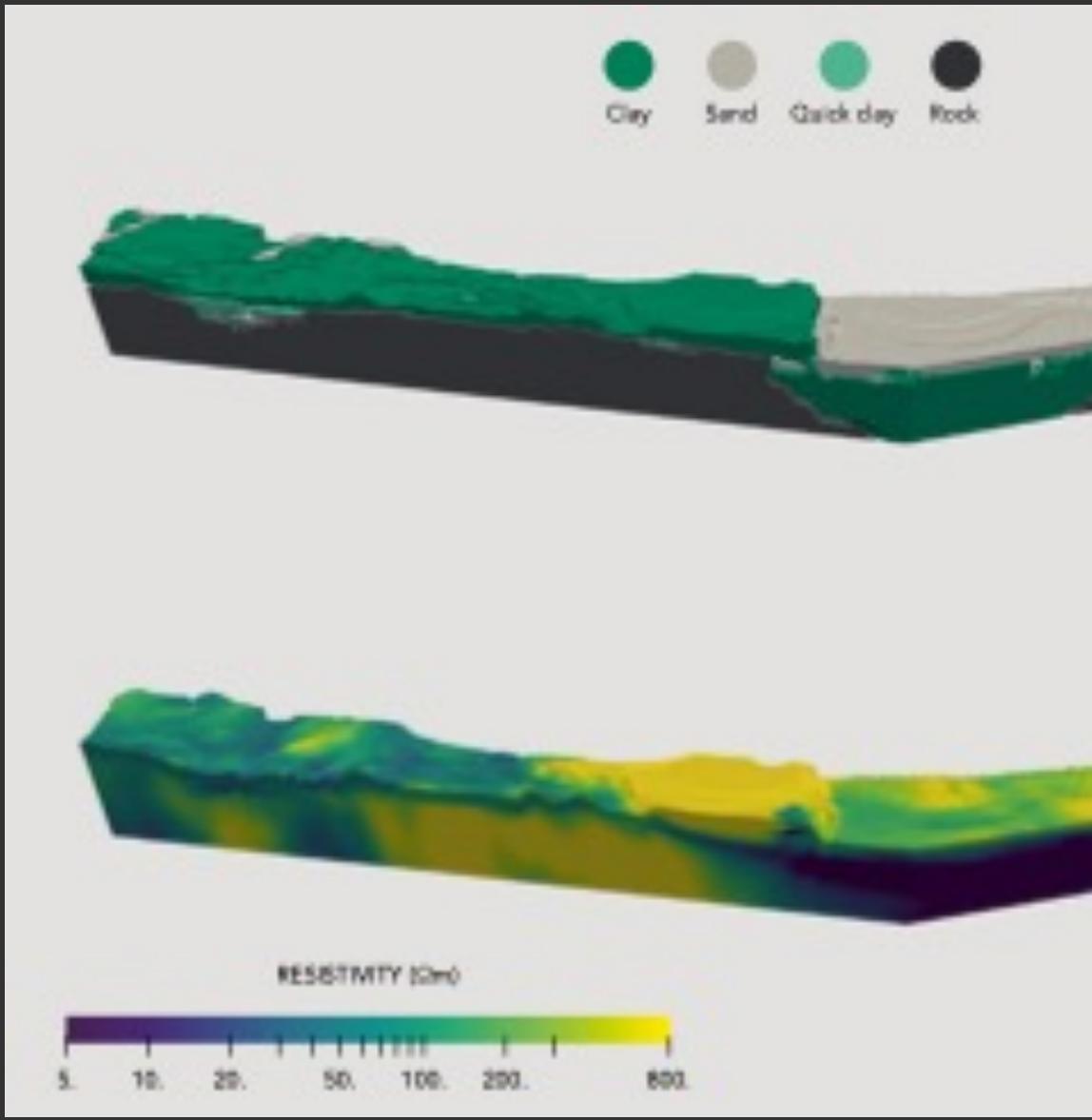


Rock types



Differences in Sediment Resistivity

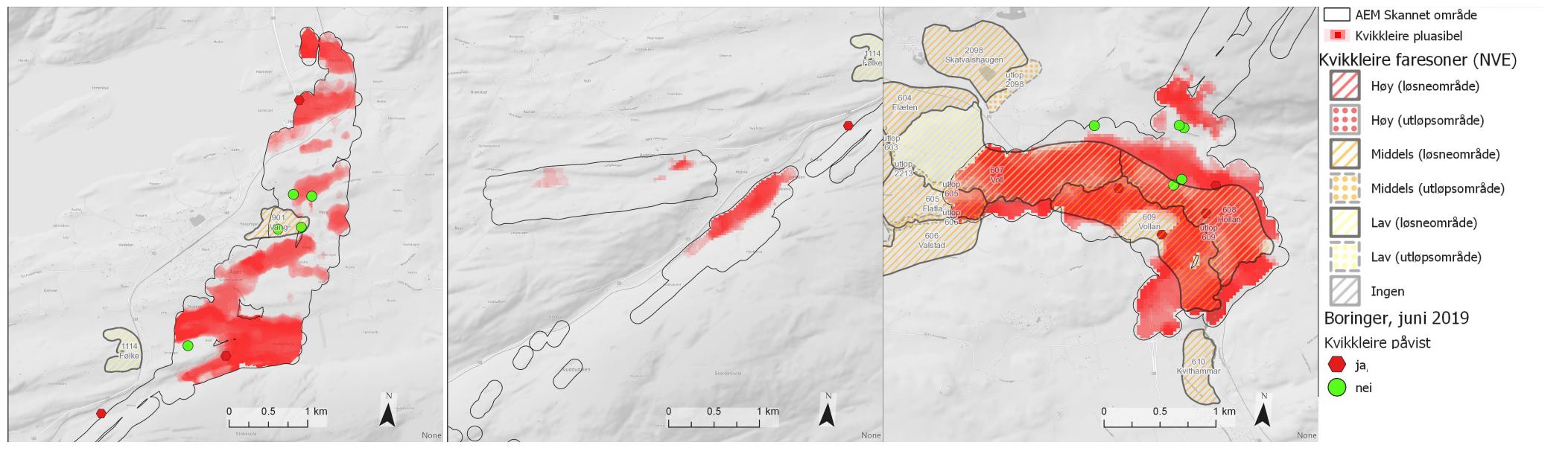




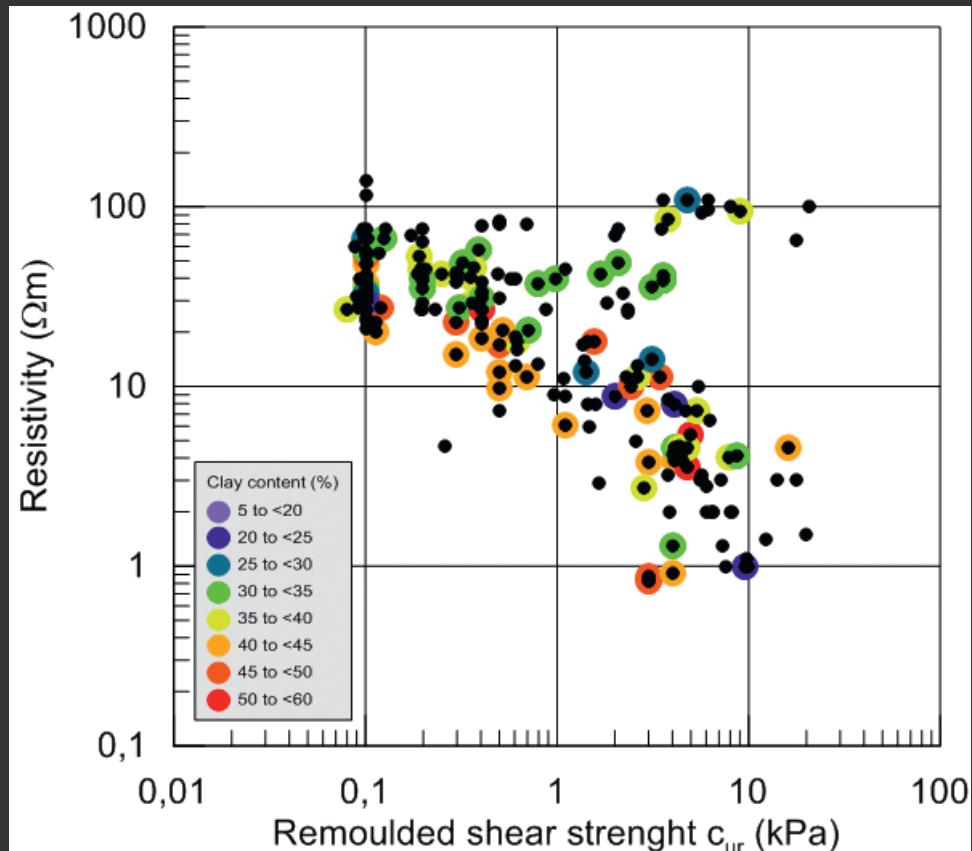
From shades
of blue-green-
yellow
to
soil types



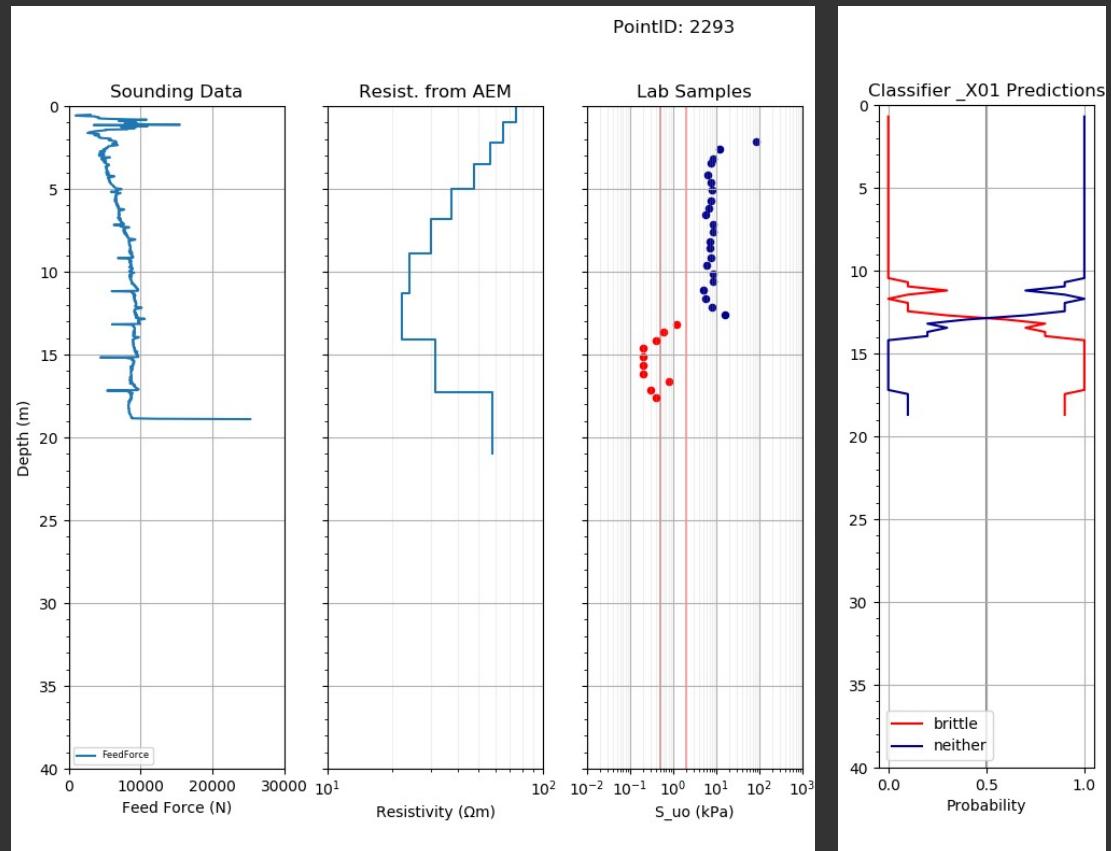
Unsupervised clay occurrence

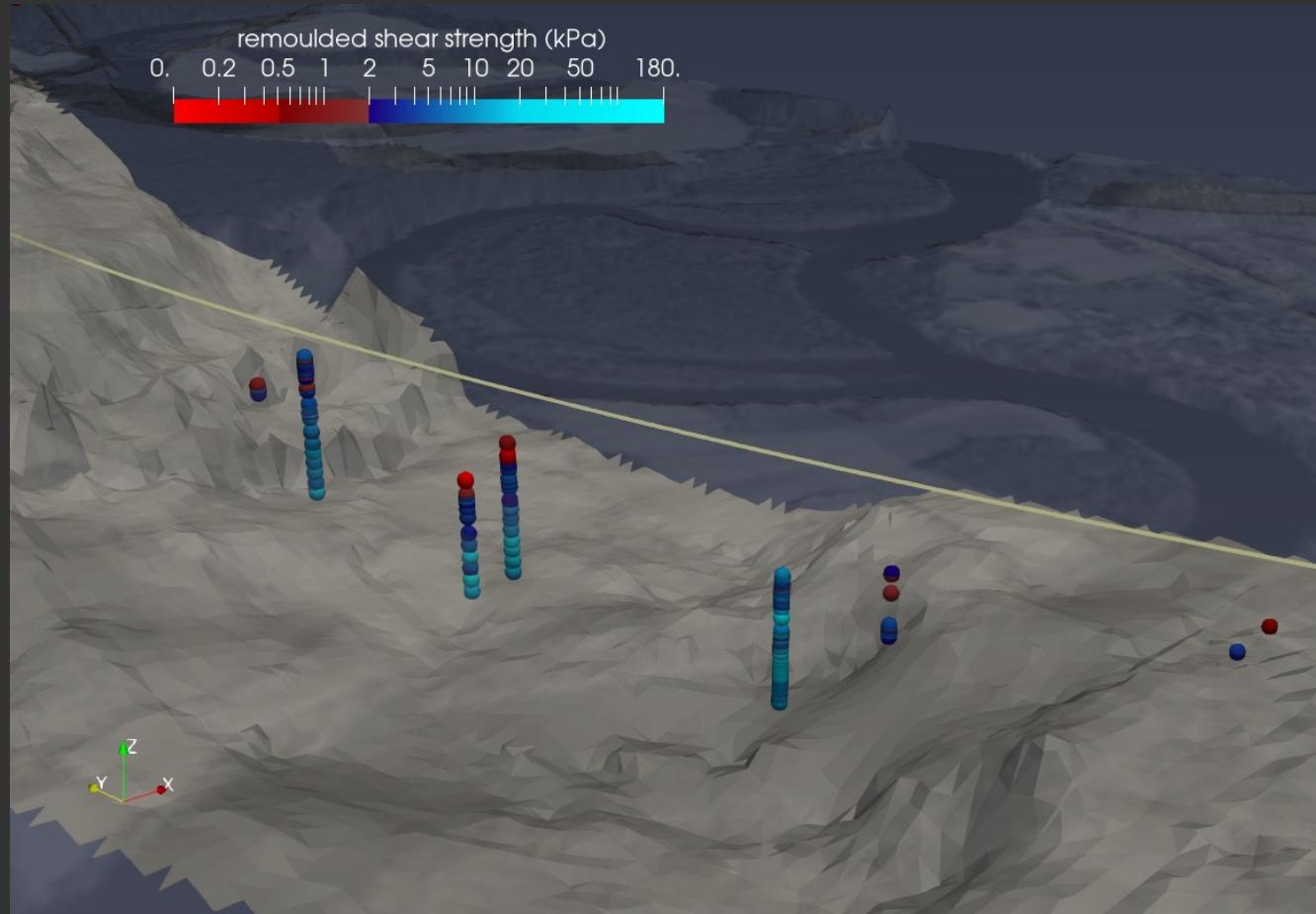


Geotechnical vs geophysical properties

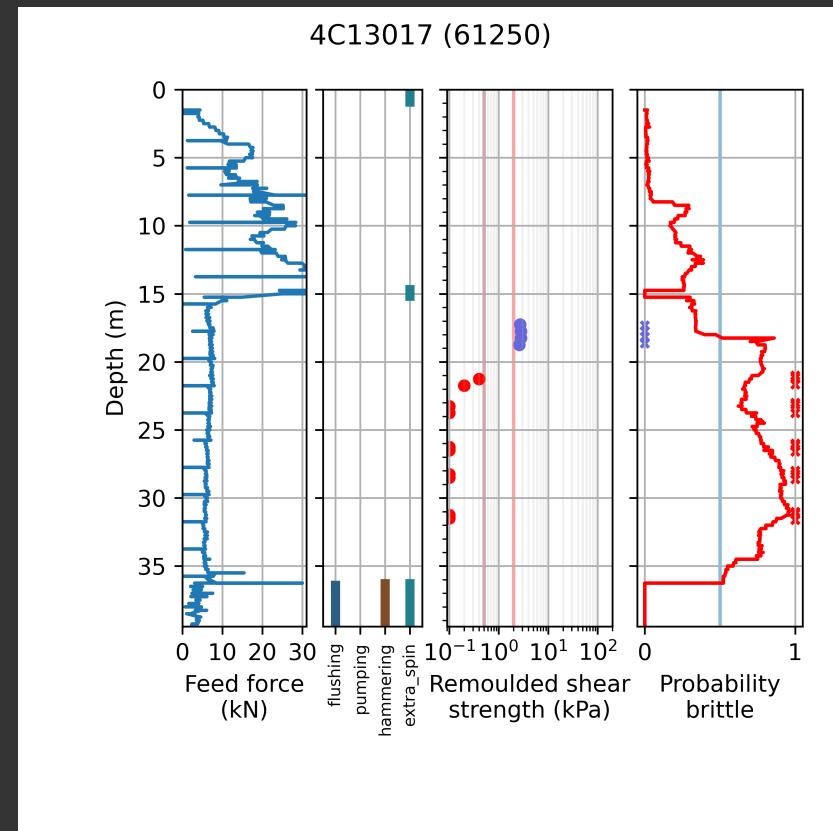


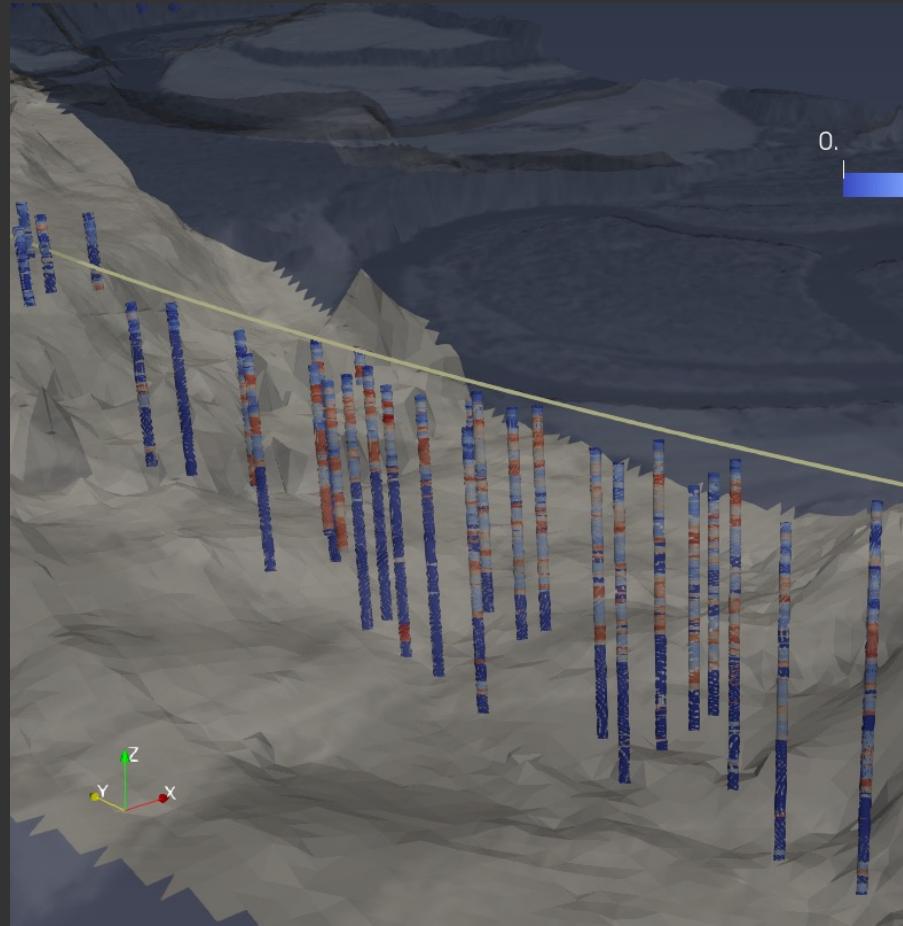
Long et al. 2017





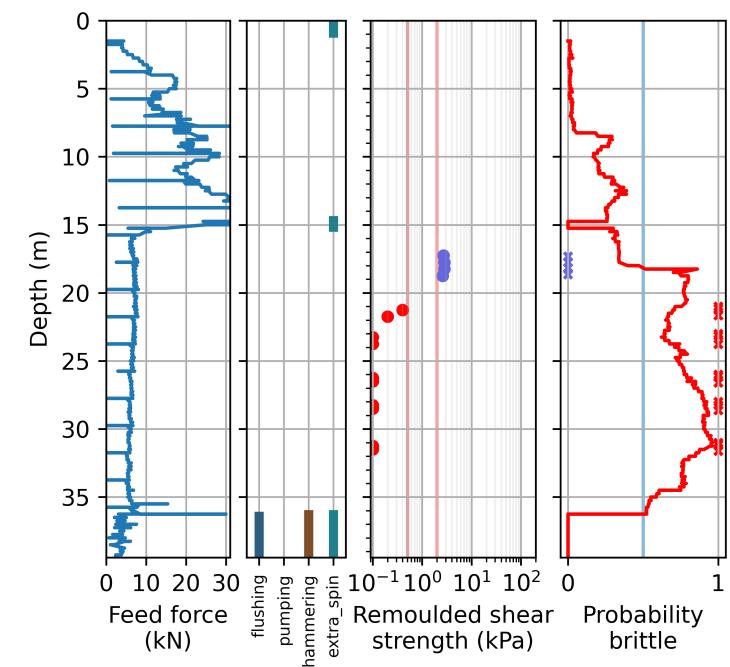
Borehole classifier

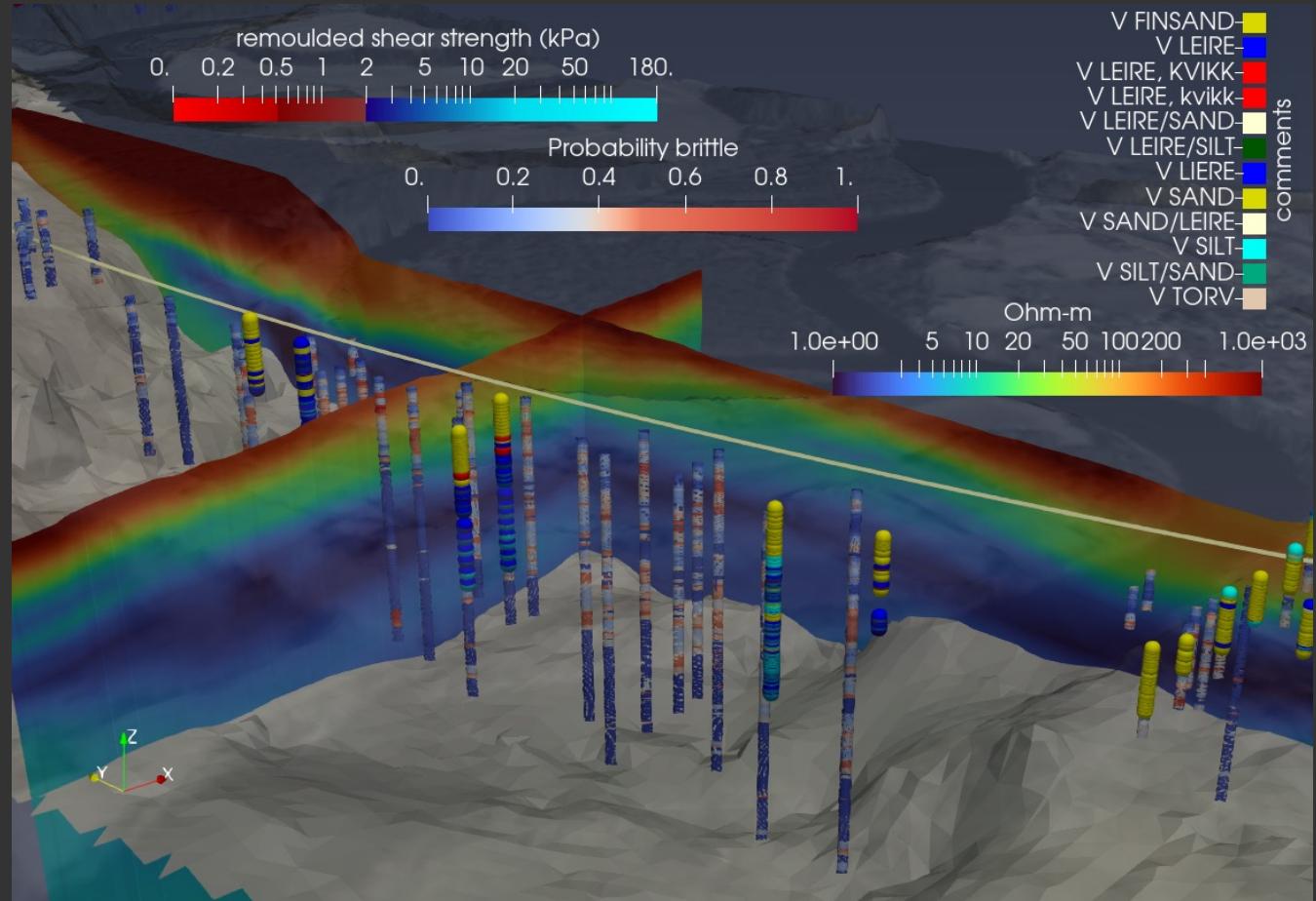


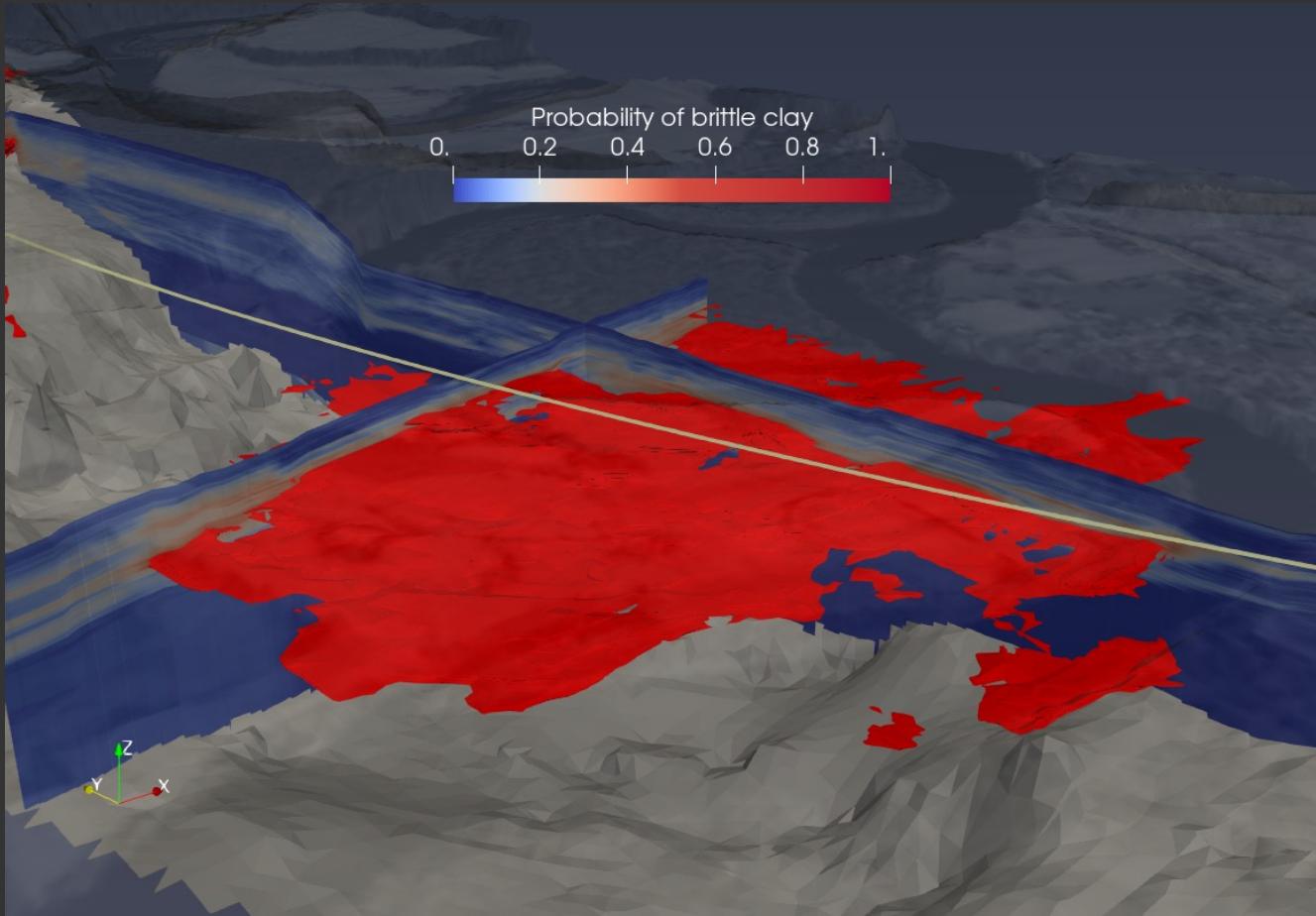


Probability brittle

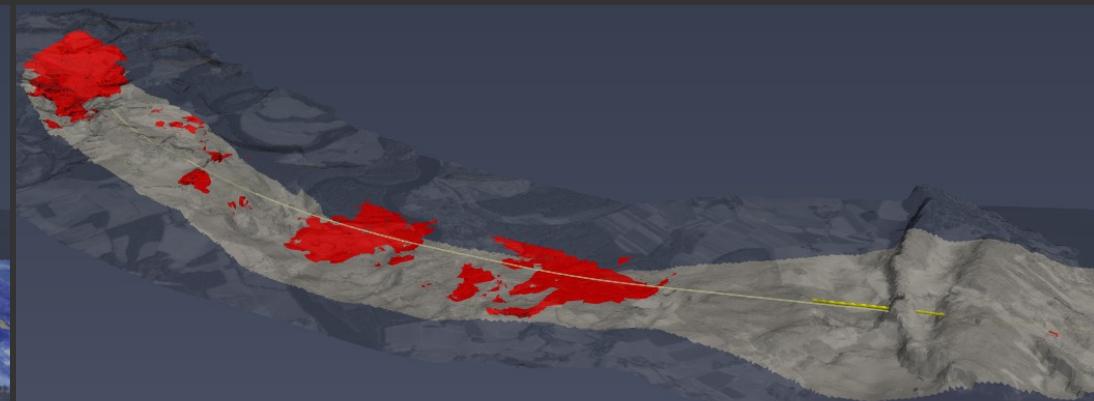
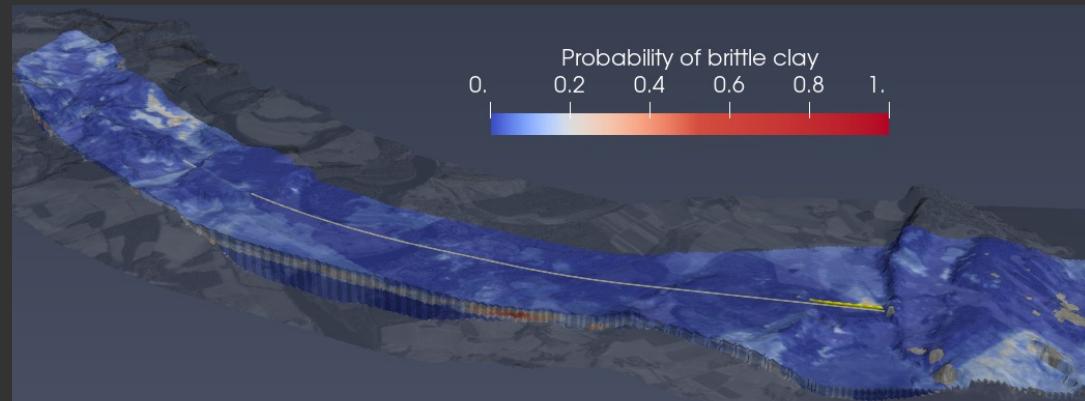
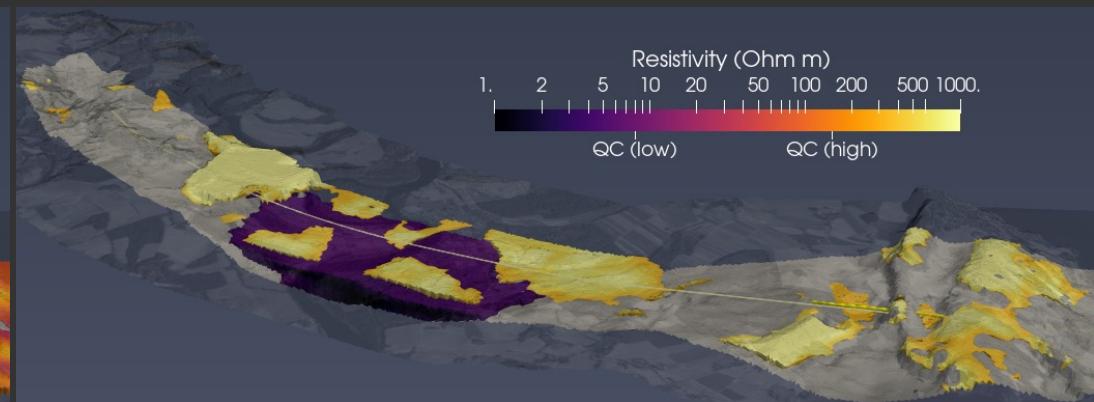
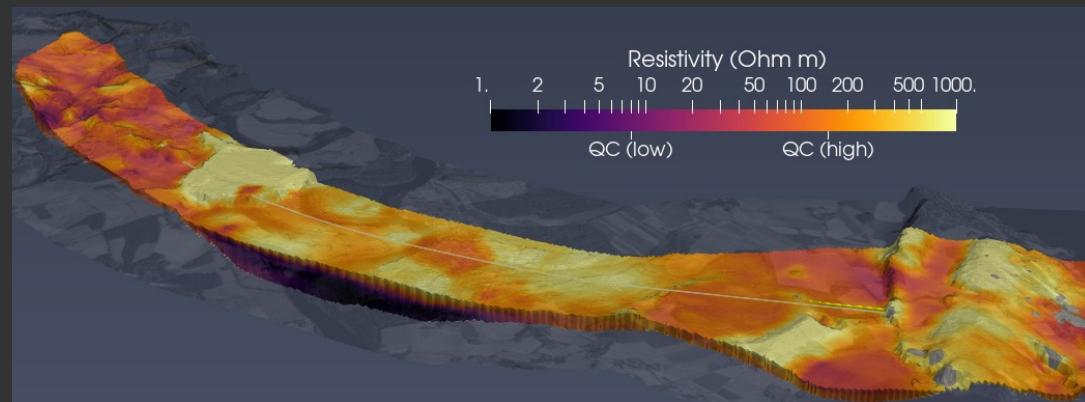
4C13017 (61250)



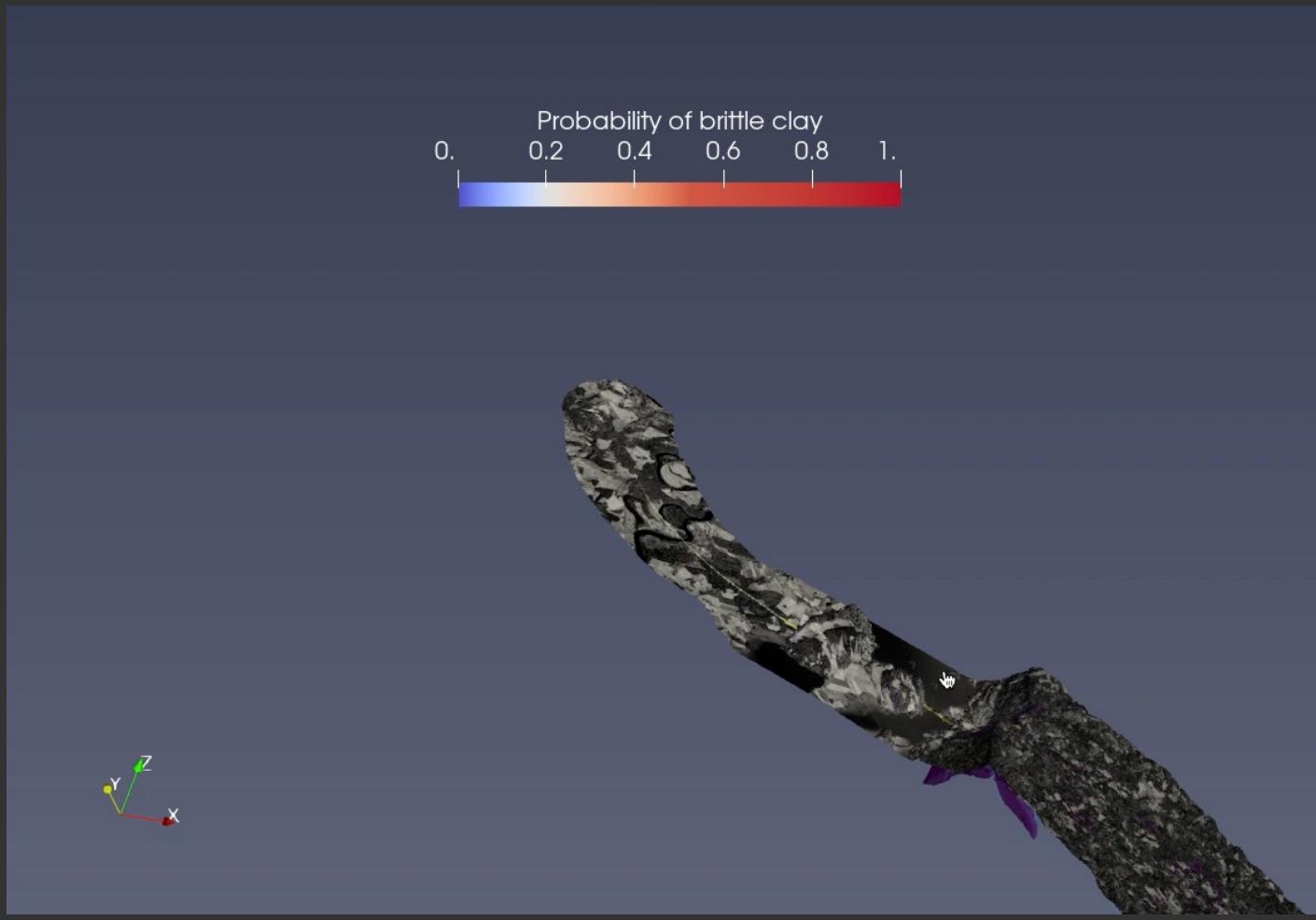




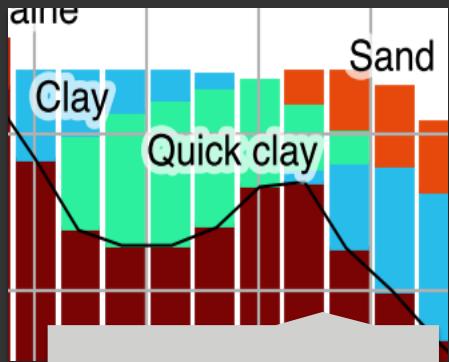
Quick clay mapping



Video demo : Brittle Clay and Resistivity



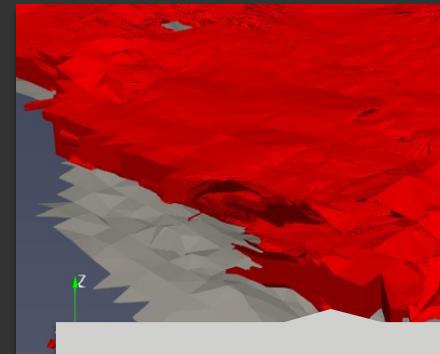
Focus areas



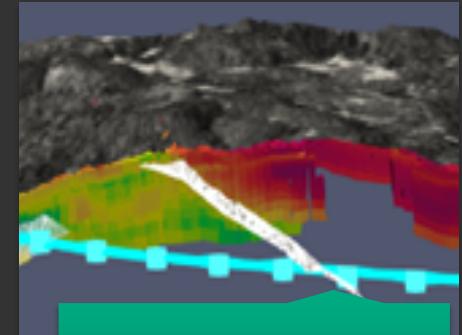
Fundamentals



Soil / Rock



Soil types

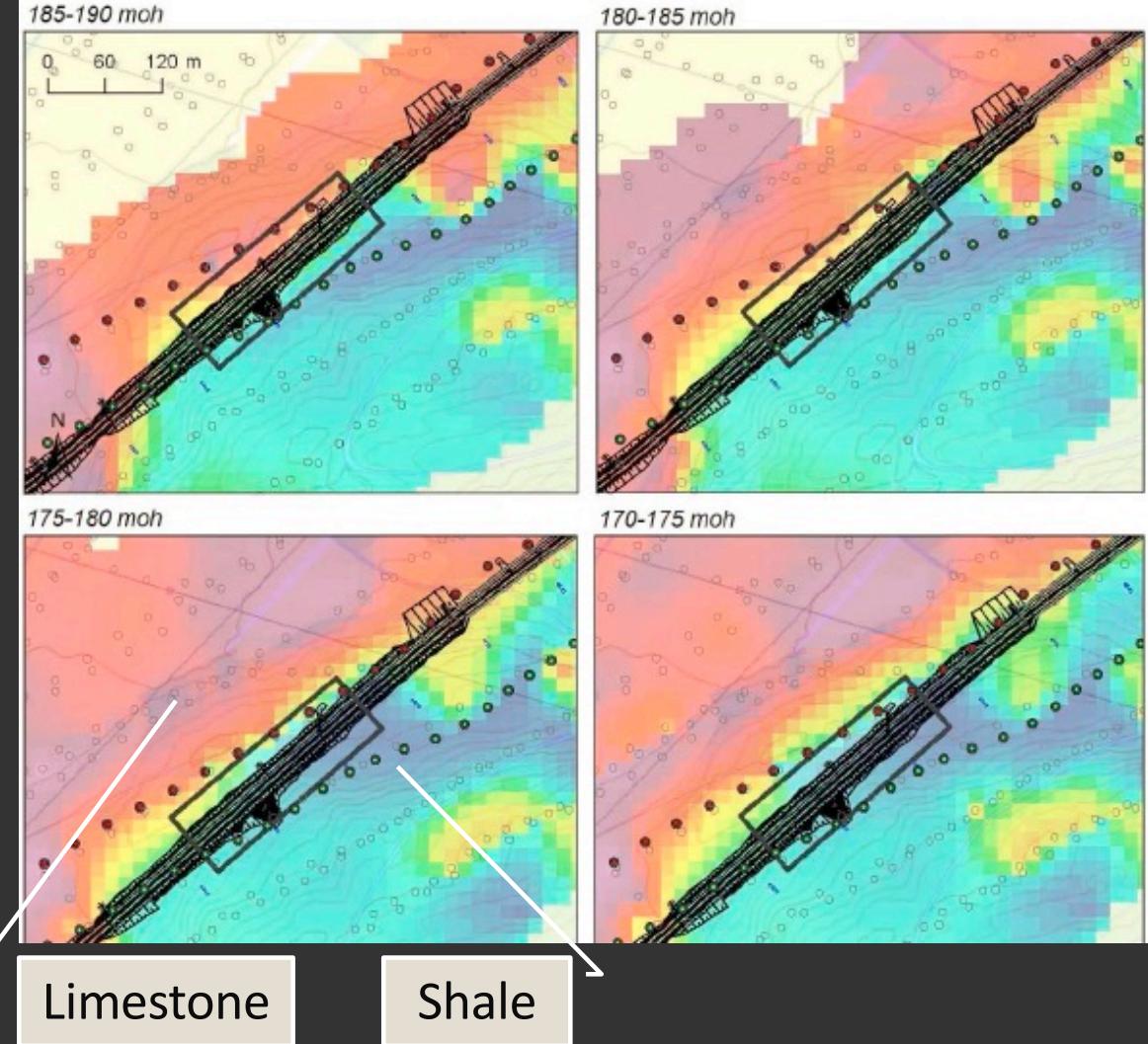
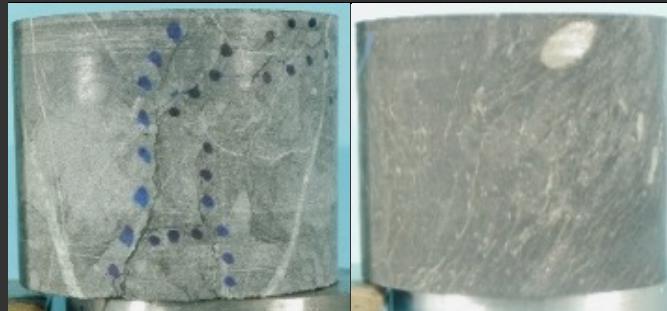


Rock types

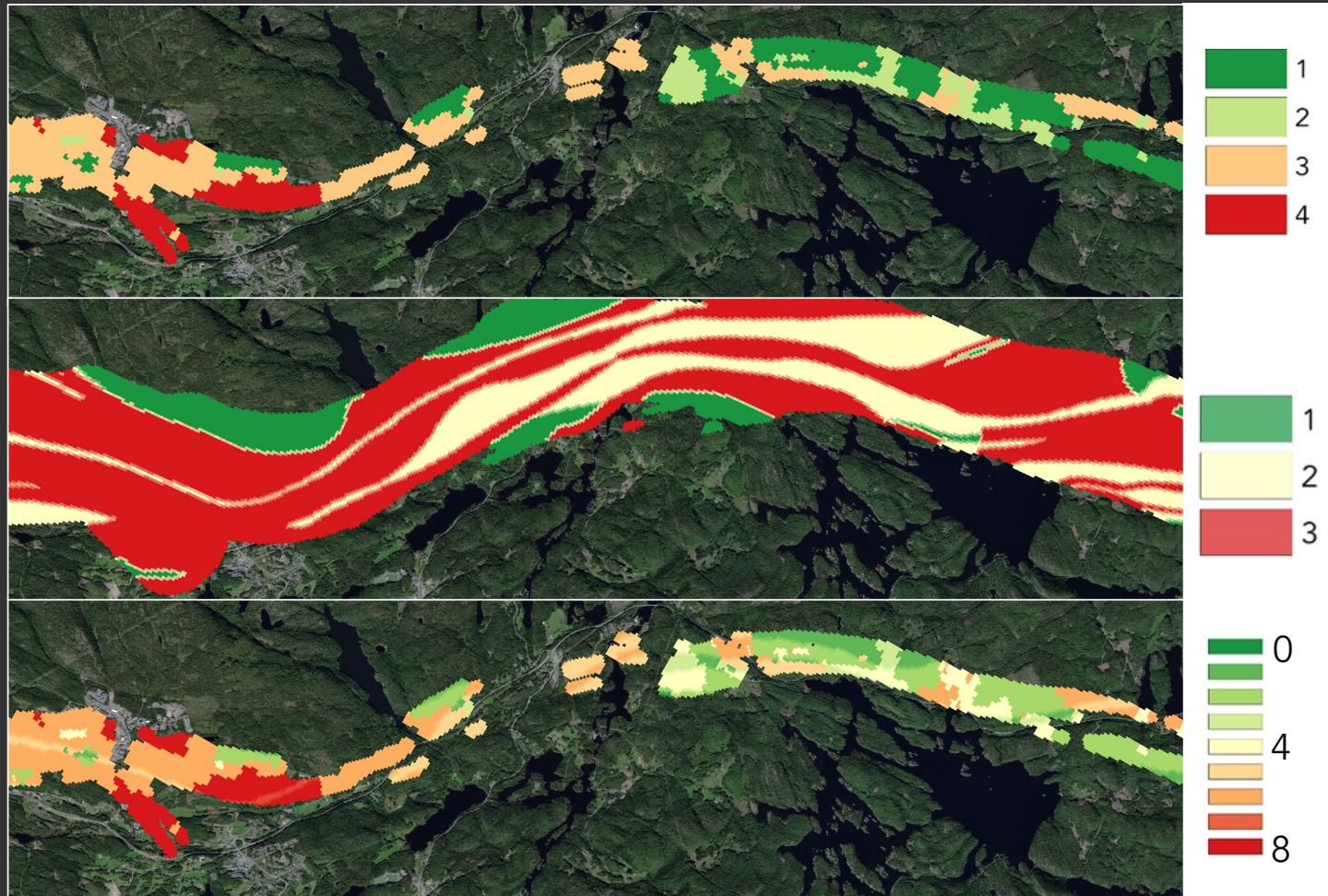


Rock properties

- Alum shale risk management



Sulfidic rock hazard mapping

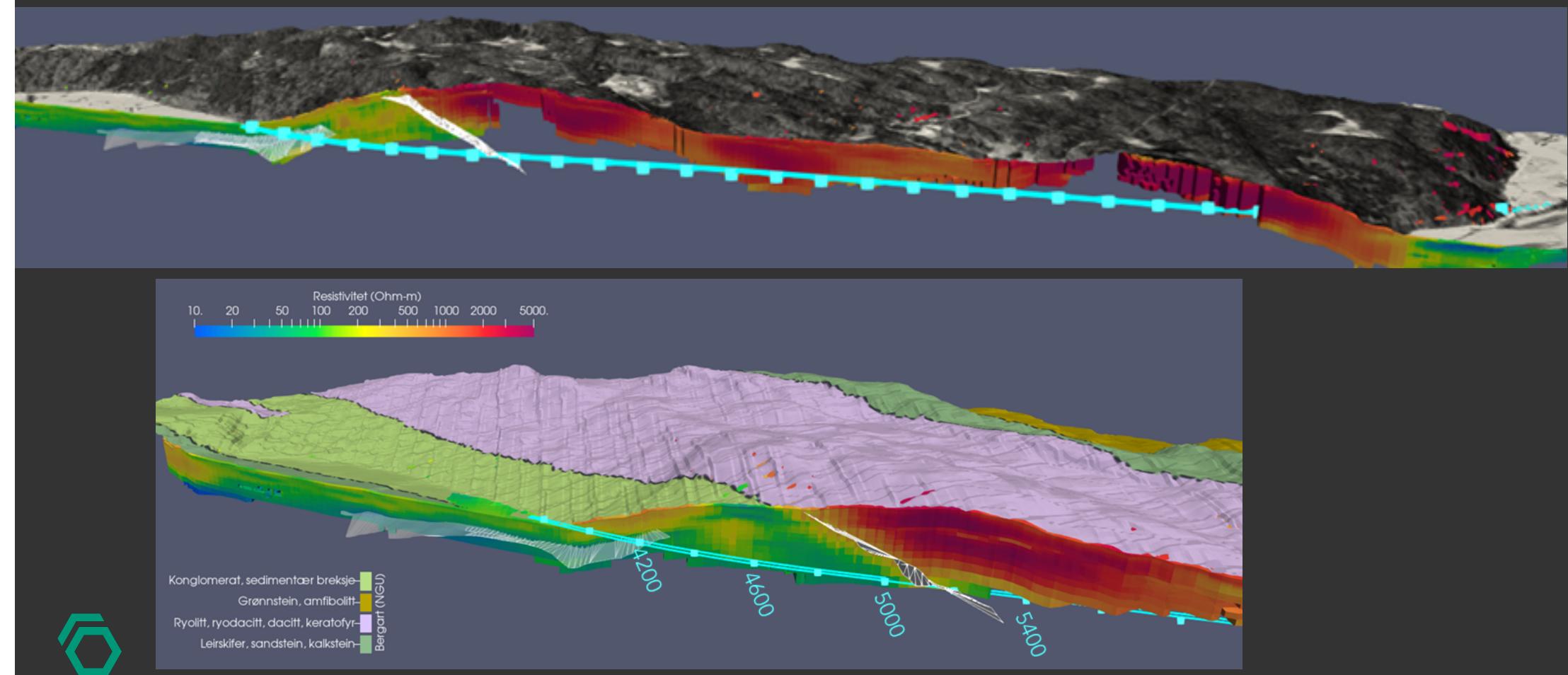


Geophysics

Lithology

Combined Output

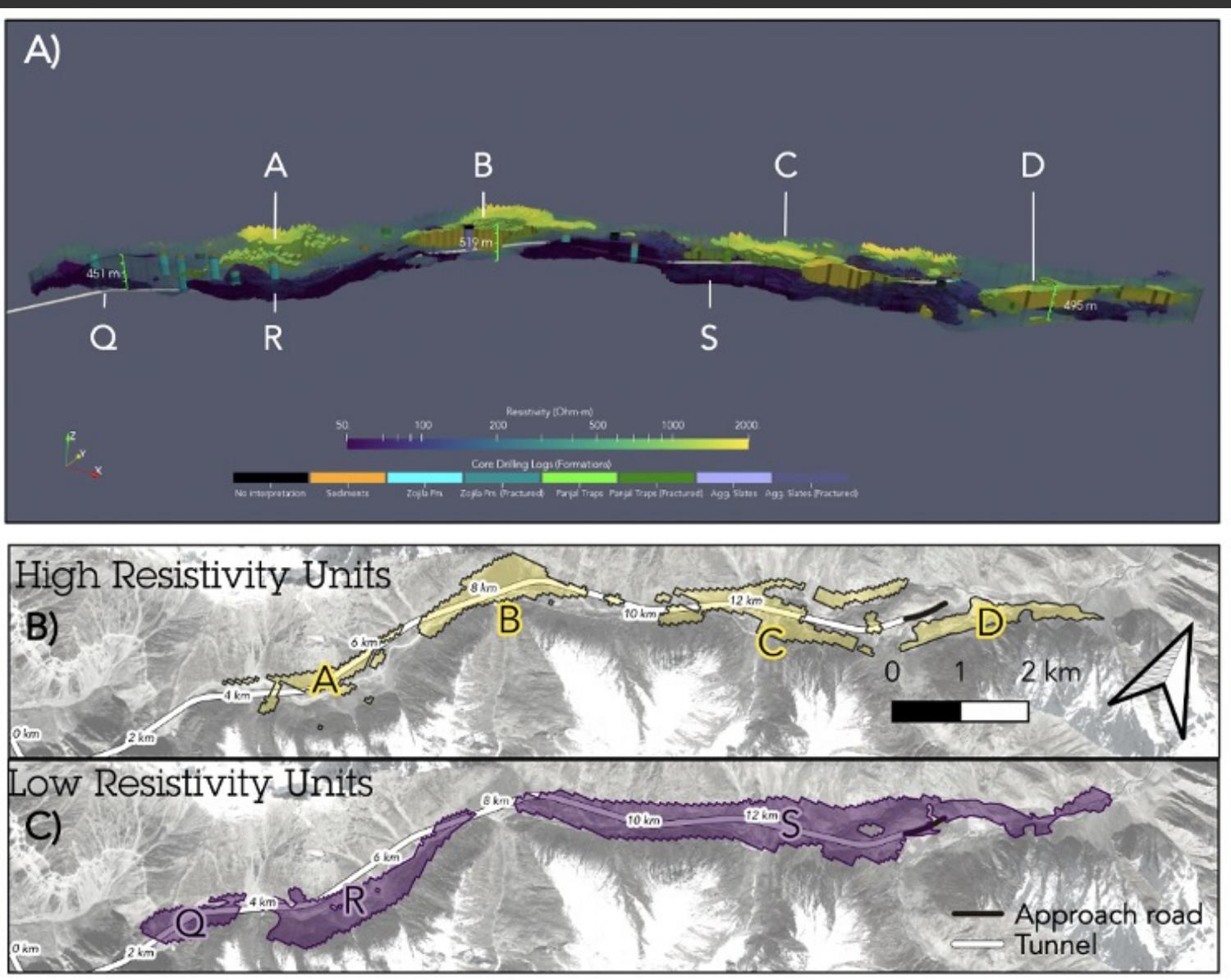
Geological boundary



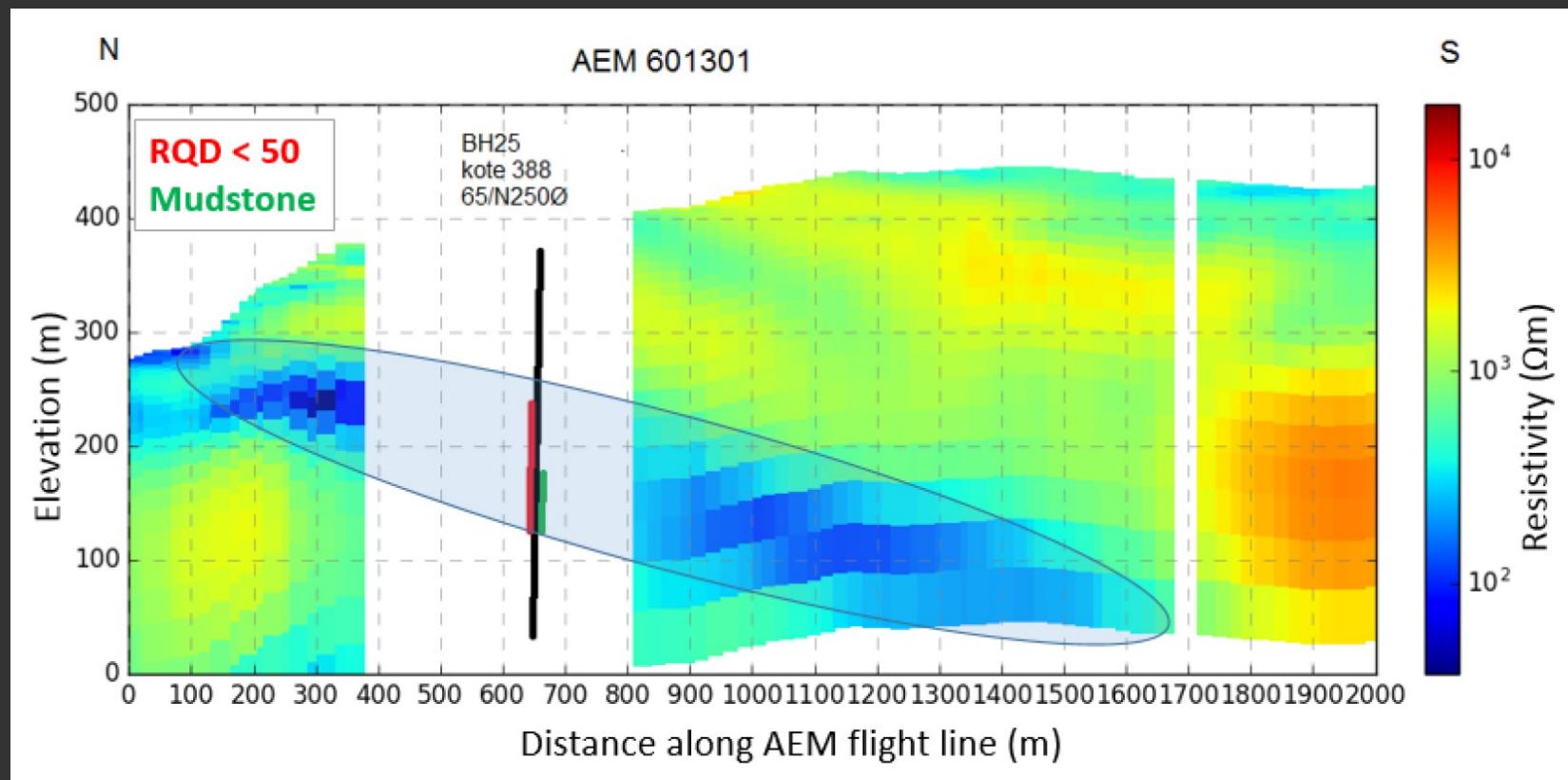
“Extreme” tunnel pre-investigations



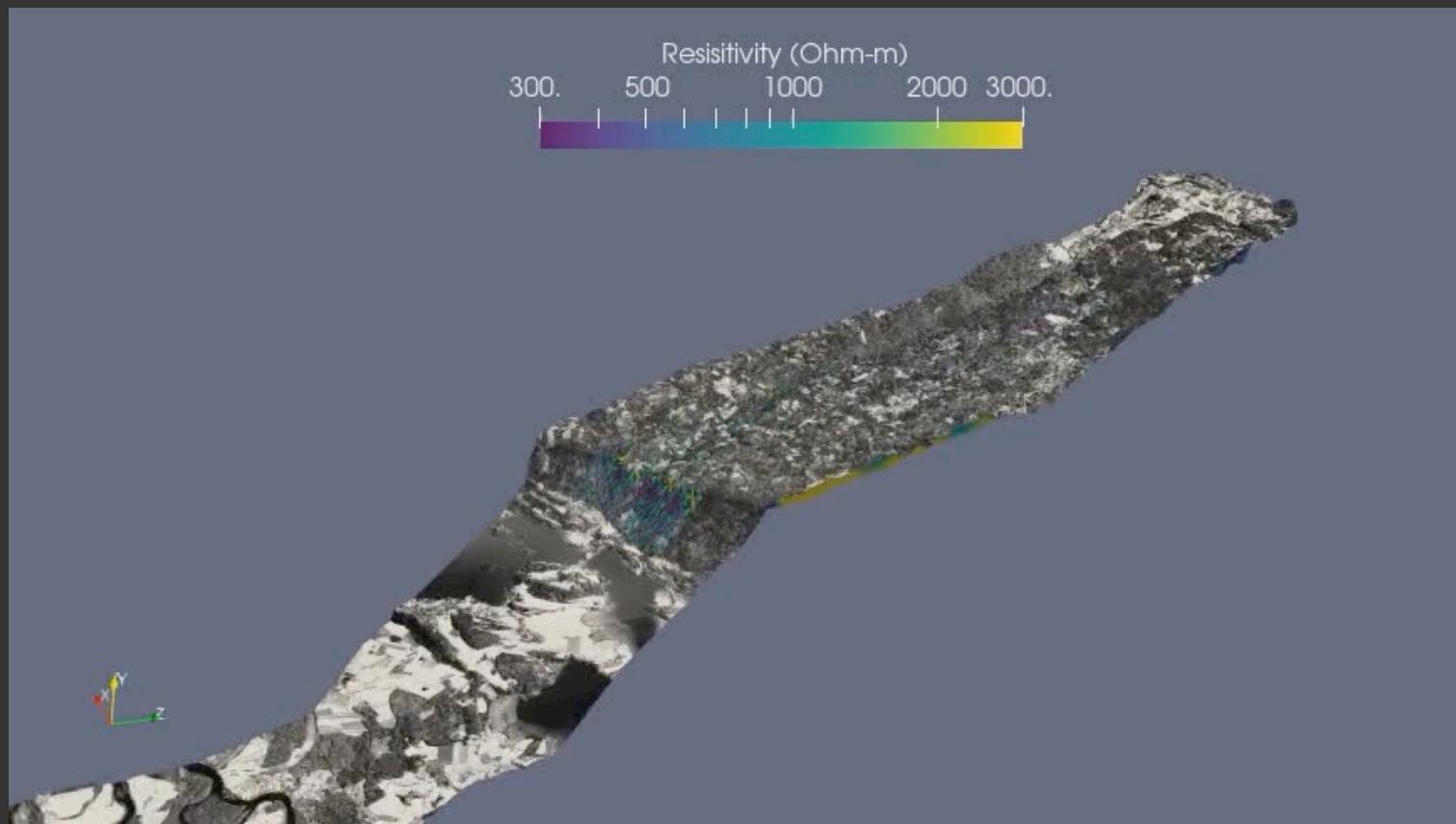
Weak vs Competent rock types



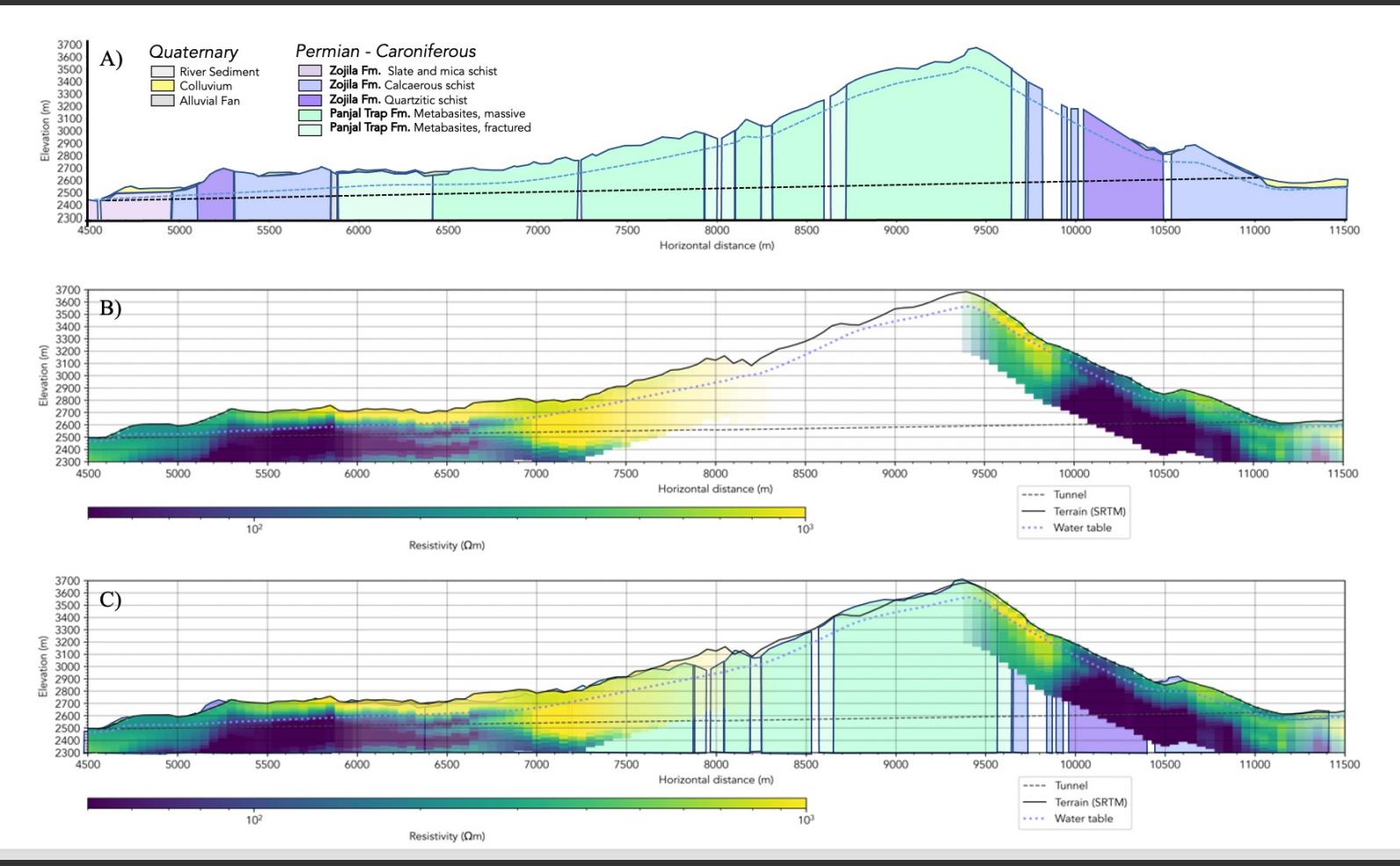
Indicated zone confirmed by coredrill



Weakness zones along tunnel alignment



Dry vs water saturated rock



Value Proposition



- Rapid early phase overview
- Quantified uncertainty
- Dynamic ground model

	In situ	Airborne
Price	X * 1 000 000 \$	X * 100 000 \$
Acquisition	Weeks to months	Days to weeks
Reporting	Static	Dynamic



Opportunities

- Can fly almost everywhere



Steep terrain



Dense forest



Snow cover



Water



Private land

Limitations

- Couplings to infrastructure

Powerlines



Major roads



Habited areas



- Flight weather

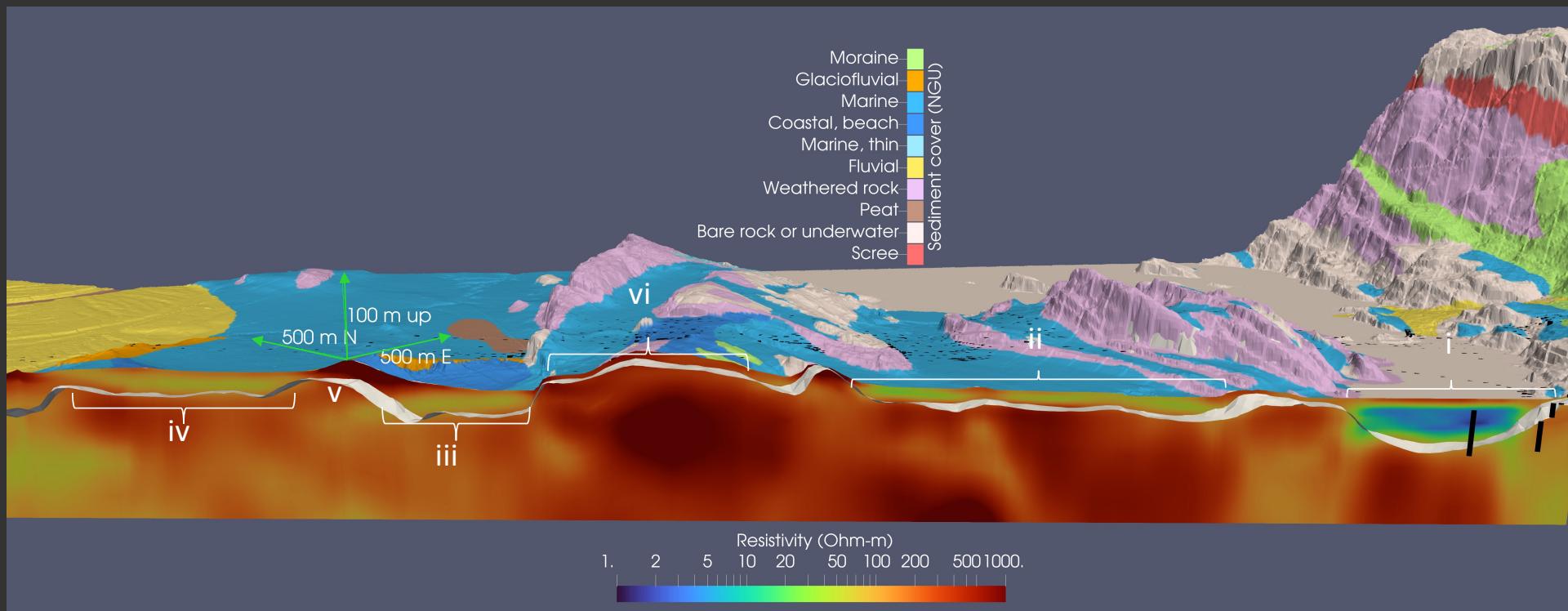
Heavy wind, fog



Fundamental challenge: Lack of contrast



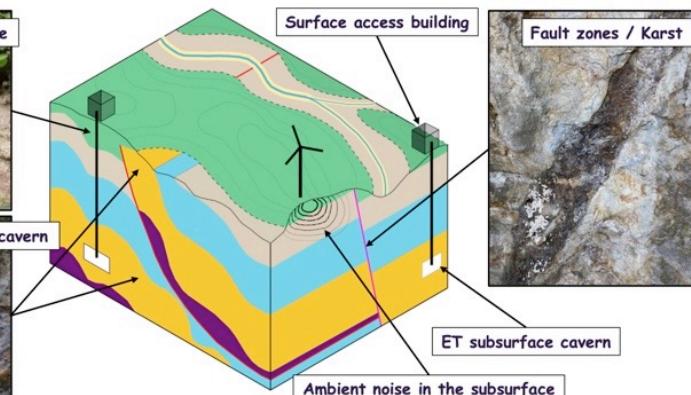
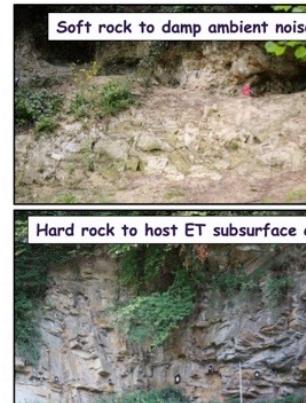
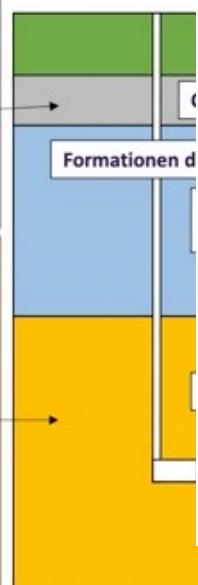
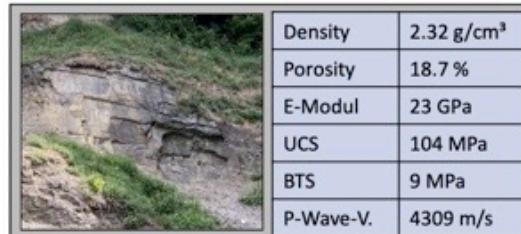
Real world complexity - (always has some contrasts ;-)



Einstein Telescope – EMR Region

Geological Assessment of Representative Rocks within ET-Project

Boundary Conditions



(Zinser, 2021)



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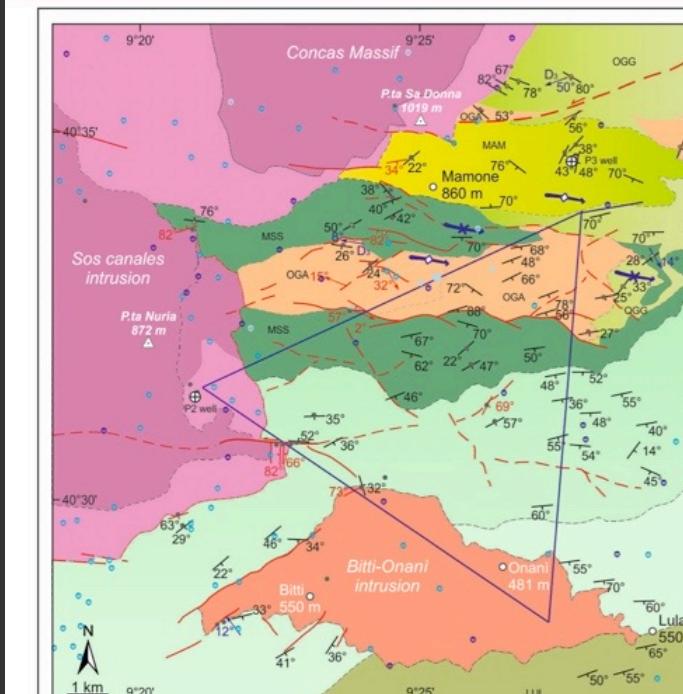
17



Einstein Telescope – Sardinia

A NEW STRUCTURAL MAP

ERT RESULTS AT ONANI' BOREHOLE



We have merged the lithologic information from public satellite images) and added new data collected in the field.

